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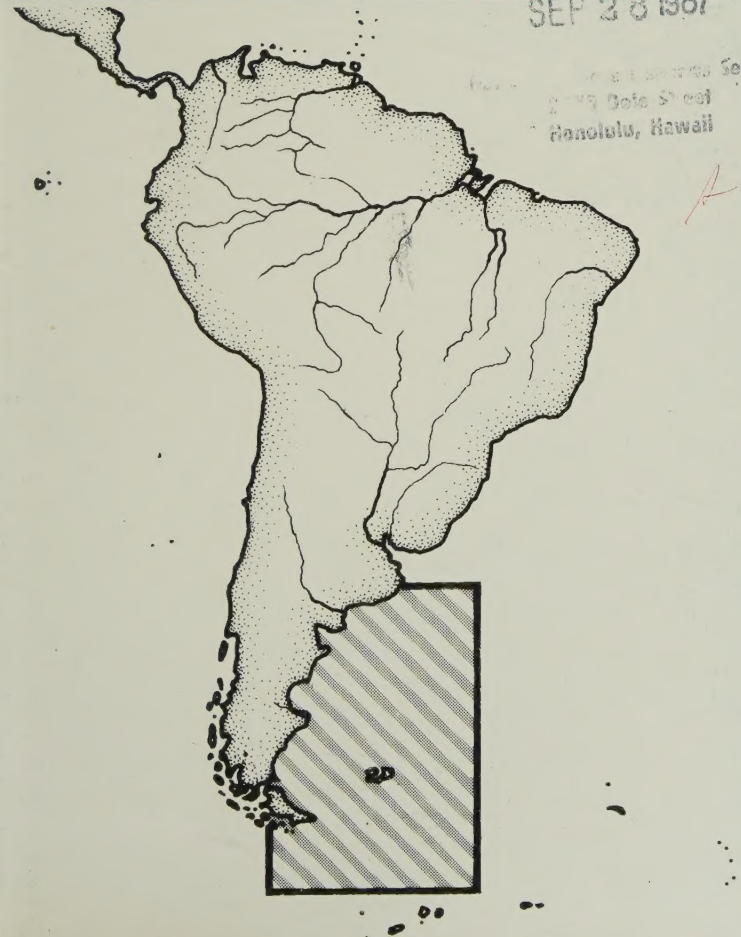

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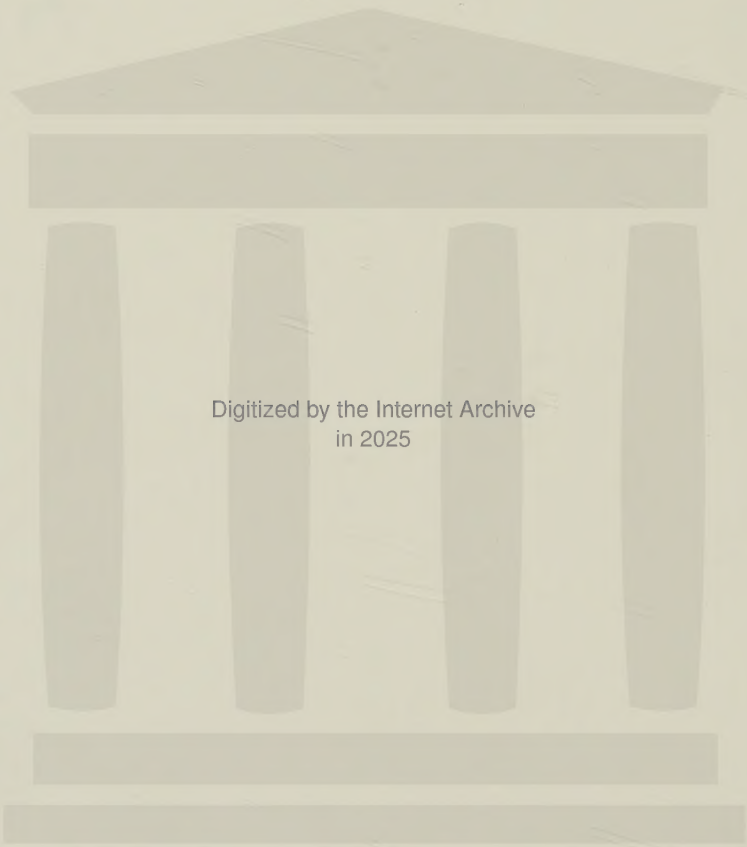

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The Patagonian fishery resources and the offshore fisheries in the South-West Atlantic

by
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Rome, 1987

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PREPARATION OF THIS DOCUMENT

One of the major programmes of FAO is the preparation of reviews of the main fishery resources and fisheries of the world. FAO has been following very closely the development of the offshore fisheries in the South-West Atlantic almost since this started, and due to the great importance of those fisheries and the fishery resources in the region, in November 1985, on the occasion of the Twenty-third Session of the FAO Conference, the Director-General decided the preparation of this study.

A first draft of this study was completed in November 1986, and had a restricted distribution to gather the opinion and comments of the main countries that had contributed with information and data on the resources and fisheries in the region. This document was completed and sent for printing in March 1987.

Distribution:

FAO Fisheries Department
FAO Regional Fisheries Officers
Directors of Fisheries
Marine Sciences (general)

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ABSTRACT

The state of the main fishery resources exploited by the offshore fleets in the South-West Atlantic is examined and some suggestions are made regarding research and management of the offshore fisheries in the region. Common hake (Merluccius hubbsi) is mostly caught in the northern Patagonian Shelf and off the River Plate Basin area and the resource seems to be lightly to fully exploited. Southern blue whiting (Micromesistius australis) is mostly caught over the Patagonian Shelf and Slope around the Falkland Islands (Malvinas) and the resource seems to be lightly to moderately exploited. Shortfin squid (Illex argentinus) is mostly caught in the offshore Patagonian Shelf and Slope from the area off the River Plate to the northern part of the Falkland Islands (Malvinas), the abundance and annual catches are highly variable and until 1985 the resource was reasonably exploited but it is likely that the increased fishing effort in 1986 may have driven the stock to an overfishing situation. A variable fishing effort policy is suggested to manage this fishery in view of the great fluctuations in recruitment strength. It seems that the common squid (Loligo sp.) stock is fully exploited with a high probability of becoming overexploited. Some general aspects regarding the state of other fish resources and of other possible effects of these offshore fisheries are also examined.

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1. INTRODUCTION AND BACKGROUND

The South-West Atlantic is one of the few major fishing areas of the world where there are still some abundant and potentially valuable fish resources which are virtually unexploited, and until a few years ago this was particularly the case of the Southern Patagonian Shelf and Slope and the Burdwood Bank area. In fact, commercial exploitation in this area only started in 1978, when Argentinian, Japanese and Polish long-range fishing fleets started to target on squids, southern blue whiting and other, so far, unexploited demersal fish resources (FAO, 1979, 1981).

Fishing effort built up rapidly in the area during the early eighties, and so did the total annual catches and the total number of countries and fishing vessels; and as the offshore fisheries developed, concern regarding a potential risk of over-exploitation also increased, mainly in view of foreseeable difficulties regarding the management of some of these fisheries.

In fact, there are certain circumstances which might hinder the possibilities of managing some of the fisheries in the area, and could make the enforcement of management measures that might be needed particularly difficult. One is that some important offshore resources occur and can be exploited both within the 200 nautical mile limit contemplated in the U.N. Convention on the Law of the Sea and where national jurisdiction could be exerted, and in the area beyond and adjacent to it, where no national jurisdiction is recognized and fisheries management seems possible only if, as stated in Article 63, paragraph 2, of the U.N. Convention on the Law of the Sea, the coastal state and the states fishing in the adjacent area agree either directly or through appropriate subregional or regional organizations upon measures aiming at the conservation of these stocks. The other very important question also recognized by the United Nations where it is being discussed in the General Assembly, refers to the controversy between Argentina and the United Kingdom regarding sovereignty rights and jurisdiction in the Falkland Islands (Malvinas) area.

When the offshore fisheries in the area were still in the initial phases of development FAO convened an Ad hoc Working Group on the Fishery Resources of the Patagonian Shelf as part of the preparations for the World Conference on Fisheries Management and Development. This Ad hoc Working Group met in Rome in February 1983 to analyze the biological and other basic scientific information available regarding the fisheries resources and fishing activities on the Patagonian Shelf and Slope, giving particular attention to the offshore resources that occur and can be exploited both within and beyond the 200 mile Exclusive Economic Zone limit, and produced a report published as FAO (1983).

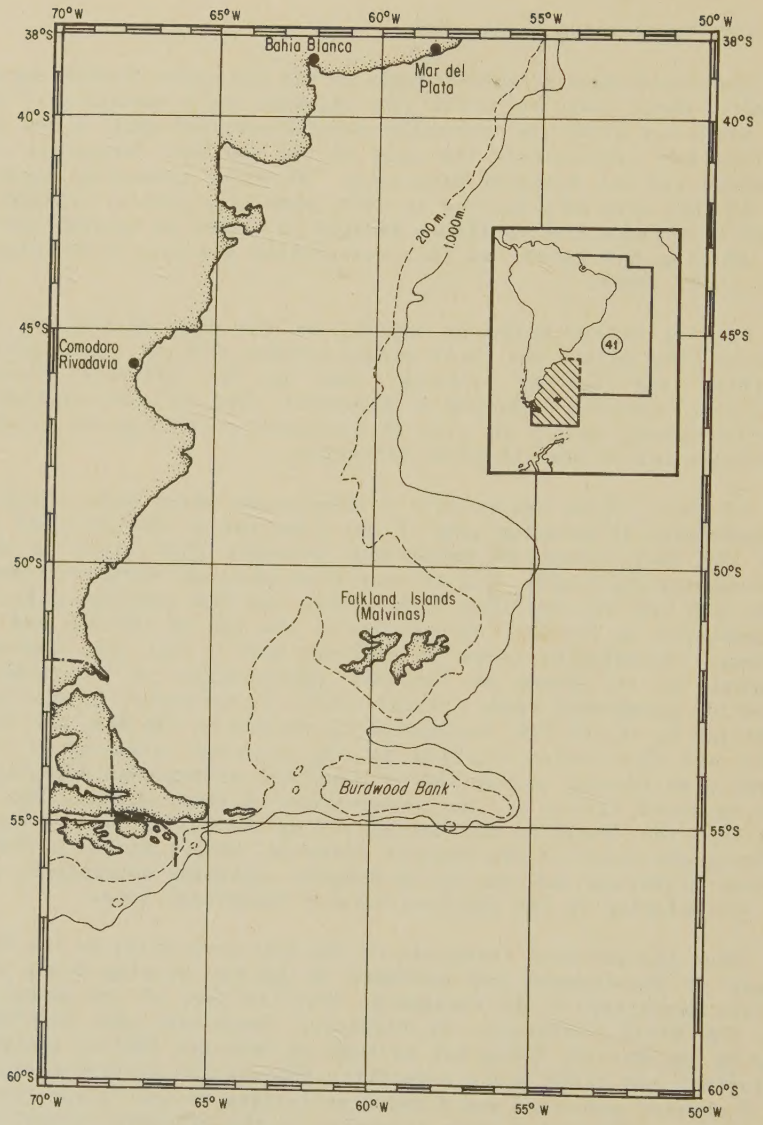

Figure 1 Map of the area considered in the study of the Patagonian fishery resources and the offshore fisheries in the South-West Atlantic

On the basis of the information available at that time, the Ad hoc Working Group concluded that none of the offshore resources were being seriously affected by fishing within or beyond the 200 mile limit, although it recognized that as fisheries develop there will be a growing need for further cooperation in that area to ensure proper conservation and utilization of the fish resources.

The outbreak of the conflict between Argentina and the United Kingdom in 1982 centred the attention of the international community on the area; and the abundant and valuable fish resources as well as the related management and conservation problems were amongst the issues that attracted the interest of part of the scientific community and of some of the main fishing nations of the world. Starting from 1982 the number of fishing countries and vessels operating in the area increased more rapidly, and so did the words of warning and concern regarding the conservation of the fish resources and the risks of such a rapid and apparently uncontrolled development of the fishing activities (FAO, 1985).

At the 23rd Session of the FAO Conference held in Rome in November 1985, the Director-General agreed that FAO should carry out, within the limits of its competence and mandate as a specialized technical agency, an assessment of the state of the fish stocks in the South-West Atlantic, including migratory stocks on the Patagonian Shelf. All countries known to fish or to have a direct interest in the fish resources in the region were informed of FAO's decision to undertake this study and, at the same time, were invited to cooperate by providing detailed information regarding their captures and fishing activities, as well as relevant research data and information. It is worth noting that most of the countries replied positively to FAO's request and, after some consultations and coordination, provided the information and data thay had available, which, in most cases, corresponded to observations made up to December 1985.

Argentina provided detailed information on the catch and fishing operations of its long-range fleet, made available data and reports of their latest fishery resources surveys, and also contributed with an updated review of the fish resources and other relevant fisheries-related issues in the South-West Atlantic (Malaret et al., 1986). Japan, one of the main fishing countries in the area, provided detailed catch and effort data as well as research results which proved to be particularly useful in the assessment of the shortfin squid. Poland, also a major fishing nation in the area, provided detailed catch and effort data and biological data, together with original research information and results (Liwoch, 1986, 1986a; and Koronkiewicz, 1986), which proved to be most useful in the assessment of shortfin squid and southern blue whiting.

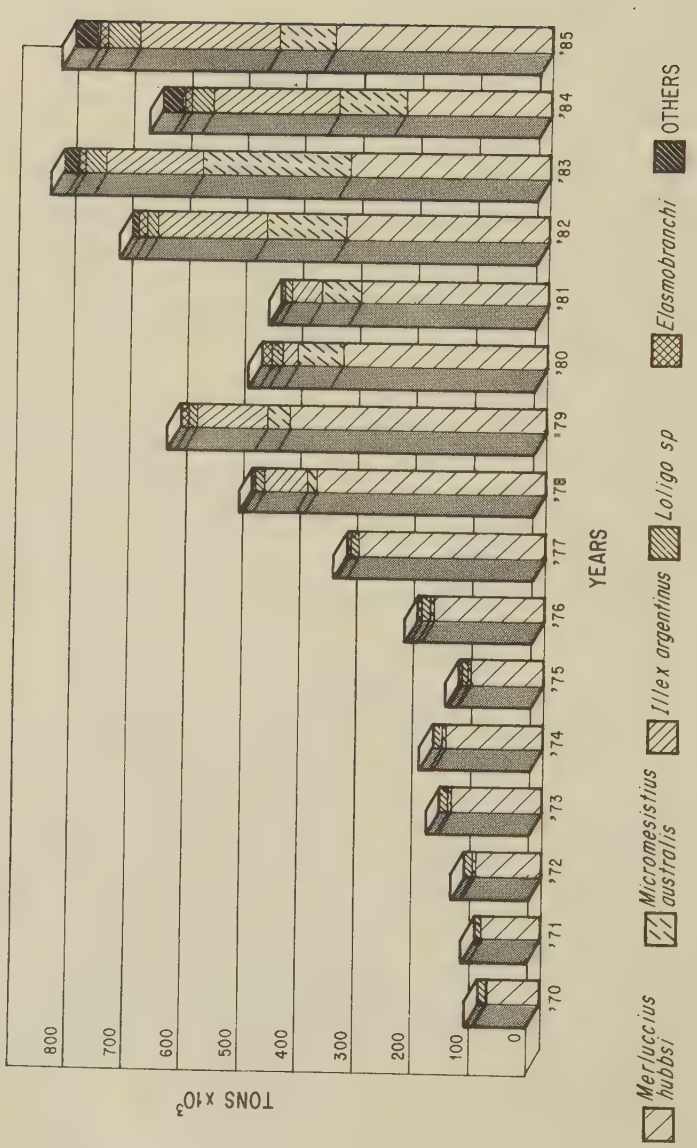

Figure 2 Total catch by species (all nations) in the South-West Atlantic, years 1970-85

The United Kingdom provided detailed surveillance data, with updated information on the fishing activities and estimates of fishing effort and catches of all fleets fishing around the Falkland Islands (Malvinas) since September 1983, together with original assessments and analyses of their own data in a technical report by Beddington, Brault and Gulland (1985) which was updated periodically through a series of interim reports by the Marine Resources Assessment Group (MRAG, 1986, 1986a, 1986b and 1987). Uruguay also provided detailed catch and effort data and resources research results regarding their fisheries and fish resources in the area off the River Plate basin.

Bulgaria, the Democratic Republic of Germany and the Republic of Korea also provided information concerning their limited past experience in the area and reported on their total annual catches by species and total number of vessels used until 1985. No detailed information regarding fishing grounds, catch per unit of effort or size-age-frequency distribution in their catches was available from these countries. It is hoped, however, that this type of data will be available from these and other countries in the future. The only data available from the other countries fishing in the area are the total annual catch by species reported annually in the FAO Yearbook of Fisheries Statistics.

For practical purposes this study is limited to the offshore fisheries in the south-western part of FAO's Statistical Area 41, limited to the North by latitude 38°S and to the East by longitude 50°W (Fig. 1), where the twelve species or groups of species listed in Tables 1 and 2 represent more than 98% of the total catches.

1.1 Total Catches and Main Fishing Countries

The total catches in the area increased from 106 thousand tons in 1970 to a maximum of 812 thousand tons in 1983, and dropped in 1984 and 1985 to 677 and 809 thousand tons respectively. Until 1977 most of the catches corresponded to hake (Fig. 2), while noticeable catches of squid, southern blue whiting and other offshore species started to be reported only in 1978. The total catches by species and by country for the period 1970-1985 are presented in Table 2.

The main fishing nations in the area by volume of their catches are: Argentina, Poland, Japan, Uruguay, Soviet Union, Spain, Bulgaria, Democratic Republic of Germany, Republic of Korea and, only since 1985, Cuba. Summaries of the total catches by country for the years 1970 through 1985 are presented in Table 3 and Fig. 3.

Argentina mostly operates in the area off the River Plate basin and the northern Patagonian Shelf, although in the past, between 1979 and 1982, part of the the Argentinian catches came from the southern

Table 1

List of selected species of potential value that can be found on the Patagonian Shelf and beyond 200 n mi from the coast in the South-West Atlantic

Scientific name	Spanish name	English name
Merluccius hubbsi	Merluza común, Merluza argentina	Common hake, Argentine hake
Merluccius polylepis (= *M. australis*)	Merluza austral, Merluza patagónica	Patagonian hake
Micromesistius australis	Polaca, Polaca austral	Southern blue whiting
Macruronus magellanicus	Merluza de cola	Patagonian grenadier, Patagonian whiphake
Salilota australis	Bacalao criollo	Tadpole mora
Macrourus whitsoni	Granadero	Grenadier
Genypterus blacodes	Abadejo, Congribadejo rosado	Pink cusk eel
Dissostichus eleginoides	Merluza negra	Patagonian toothfish
Notothenia spp.	Nototénias	Southern cods
Illex argentinus	Calamar argentino, Pota, calamar	Argentine shortfin squid, Shortfin squid
Loligo spp.	Calamarete, Calamar común	Common squid
Elasmobranchii	Tiburones, rayas	Sharks and rays

Table 2

Nominal catches by species and by country in the South-West Atlantic, years 1970-85 [1/, 2/]

species / countries	Total catch in metric tons															
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Merluccius spp.																
Argentina	87 400	92 000	102 800	151 400	162 200	109 000	174 906	273 630	341 161	370 905	277 350	228 729	281 909	257 100	182 626	259 334
Bulgaria	-	-	-	-	-	-	-	858	-	-	-	-	-	-	25	166
Cuba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	29
Germany D.R.	-	-	-	-	-	-	-	-	-	68	-	-	-	-	-	-
Germany F.R.	-	-	3 900	-	-	-	-	-	5 636	3 385	-	-	-	-	-	-
Japan	-	-	-	-	-	138	690	82	9 330	4 012	4 210	328	-	3 632	2 984	3 303
Poland	-	-	-	-	-	-	-	-	-	8 206	7 720	1 575	3 359	1 177	400	2 848
USSR	300	2 500	100	-	2 100	-	74	22 044	-	1 633	3 580	12	361	1 724	237	517
Uruguay	3 700	3 700	8 500	4 500	1 500	9 847	11 675	22 511	41 323	57 057	62 309	92 268	68 029	79 692	65 051	97 150
Total	91 400	98 200	115 300	155 900	165 800	118 985	187 345	319 125	397 450	445 266	355 169	322 912	353 658	343 325	251 327	363 347
Micromesistius australis																
Argentina	-	-	-	-	-	-	-	-	2 598	2 121	2 351	4 538	7 016	707	352	2 304
Bulgaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2 618	4 830
Germany D.R.	-	-	-	-	-	-	-	-	-	138	10	-	-	-	-	-
Germany F.R.	-	-	-	-	-	-	-	-	1 520	106	-	-	-	-	-	-
Japan	-	-	-	-	-	-	-	2 057	478	441	354	5	-	219	516	1 549
Poland	-	-	-	-	-	-	-	-	11 717	35 870	54 218	48 419	130 173	233 029	100 114	71 855
USSR	-	-	-	-	-	-	-	-	-	176	21 432	16 755	-	24 183	10 175	16 213
Total	-	-	-	-	-	-	-	2 057	16 313	38 852	78 365	69 717	137 189	258 138	113 775	96 751
Macruronus magellanicus																
Argentina	-	-	-	-	-	-	-	-	1 062	257	73	1 150	881	665	534	1 602
Bulgaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	165	1 106
Germany F.R.	-	-	-	-	-	-	-	-	260	37	-	-	-	-	-	-
Japan	-	-	-	-	-	-	-	-	404	12	37	12	-	361	463	317
Poland	-	-	-	-	-	-	-	-	559	5 478	6 569	1 636	2 672	3 275	4 782	18 803
Total	-	-	-	-	-	-	-	-	2 285	5 784	6 679	2 798	3 553	4 301	5 944	21 828
Macrourus whitsoni																
Germany D.R.	-	-	-	-	-	-	-	-	-	13	5	-	-	-	-	353
Germany F.R.	-	-	-	-	-	-	-	-	9	1	-	-	-	-	-	-
Japan	-	-	-	-	-	80	113	43	637	153	77	68	-	-	-	-
Poland	-	-	-	-	-	-	-	-	-	4 398	490	463	298	13	5	-
USSR	1 500	600	0	-	400	937	43	1 556	-	340	242	-	-	18 059	31 024	8 868
Total	1 500	600	0	0	400	1 017	156	1 599	646	4 905	814	531	298	18 072	31 029	9 221
Genypterus blacodes																
Argentina	1 100	1 100	2 400	1 500	2 300	1 500	3 361	2 500	5 050	7 343	6 561	4 346	8 820	9 291	3 891	9 208
Germany F.R.	-	-	100	-	-	-	-	-	91	68	-	-	-	-	-	-
Japan	-	-	-	-	-	0	56	3	453	280	188	2	-	329	411	419
Poland	-	-	-	-	-	-	-	-	-	-	-	69	17	-	-	20
Uruguay	-	-	-	-	-	20	13	79	40	52	161	282	142	672	416	905
Total	1 100	1 100	2 500	1 500	2 300	1 520	3 430	2 582	5 634	7 743	6 910	4 699	8 979	10 292	4 718	10 552

Table 2 (cont'd)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Dissostichus eleginoides																
Argentina	–	–	–	–	–	–	–	–	39	4	–	26	48	152	27	107
Bulgaria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	43	88
Poland	–	–	–	–	–	–	–	–	–	–	388	383	6	–	–	–
USSR	–	–	–	–	–	–	–	655	–	–	–	–	–	–	–	–
Total	–	–	–	–	–	–	–	655	39	4	388	409	54	152	70	195
Notothenia																
Bulgaria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2 083	3 176
Germany D.R.	–	–	–	–	–	–	–	–	10	2	–	–	–	–	–	–
Poland	–	–	–	–	–	–	–	2	110	2 982	7 436	1 257	1 209	1	30	12
USSR	–	–	–	–	–	3 452	8 325	2 750	–	–	46	–	–	10	–	5 969
Total	–	–	–	–	–	3 452	8 325	2 752	120	2 984	7 482	1 257	1 209	11	2 113	9 157
Illex argentinus																
Argentina	1 200	1 700	1 600	3 900	4 900	4 100	7 493	1 986	59 001	86 869	9 111	10 622	38 841	28 687	28 969	21 541
Bulgaria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3 200	5 543
Cuba	–	–	–	–	–	–	–	–	–	–	–	–	–	–	52	4 523
Germany D.R.	–	–	–	–	–	–	–	–	–	156	1	–	–	92	8 379	11 766
Germany F.R.	–	–	–	–	–	–	–	–	664	559	–	–	–	–	–	–
Japan	–	–	–	–	–	–	1	–	6 908	14 903	6 148	19 635	36 753	23 455	62 450	83 799
Korea, Rep.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10 588
Poland	–	–	–	–	–	–	–	–	4 366	15 048	12 902	19 042	109 304	110 342	113 367	95 961
Uruguay	100	100	200	200	100	520	773	362	2 182	4 688	715	3 085	4 106	3 609	2 745	333
Total	1 300	1 800	1 800	4 100	5 000	4 620	8 267	2 348	73 121	122 203	28 877	52 384	189 004	166 185	219 160	234 054
Loligo spp.																
Argentina	200	100	100	200	200	140	128	255	238	349	186	201	262	243	104	239
Bulgaria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1 897	2 263
Germany D.R.	–	–	–	–	–	–	–	–	–	–	7	–	–	322	530	139
Germany F.R.	–	–	–	–	–	–	–	–	661	559	–	–	–	–	–	–
Japan	–	–	–	–	–	–	1	–	12	–	8	–	–	343	298	168
Poland	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spain	–	–	–	–	–	–	–	–	–	–	–	–	–	16 000	13 000	9 200
USSR	–	–	–	–	–	–	–	99	–	17	910	430	18 190	21 348	15 621	38 528
Total	200	100	100	200	200	140	129	354	911	925	1 111	631	18 452	38 256	31 450	50 537
Elasmobranchii																
Argentina	8 400	10 300	9 600	12 500	13 600	13 000	9 687	9 611	12 962	8 722	9 574	7 068	10 926	8 109	9 440	14 005
Germany D.R.	–	–	–	–	–	–	–	–	–	37	2	–	–	–	–	–
Germany F.R.	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Japan	500	100	200	100	3	1	–	–	106	47	24	146	221	2	405	694
Korea Rep.	–	–	–	–	–	–	13	207	172	110	13	18	77	90	1 212	174
Poland	–	–	–	–	–	–	–	–	269	821	831	137	94	–	–	–
Uruguay	1 800	1 900	1 900	1 700	2 400	3 070	3 003	2 144	1 707	1 255	1 420	1 114	1 243	1 498	1 382	1 475
USSR	–	–	–	–	–	–	–	–	–	–	206	–	–	–	42	–
Total	10 700	12 300	11 700	14 300	16 003	16 071	12 703	11 962	15 216	10 994	12 070	8 483	12 561	9 699	12 481	16 348
Grand total	106 200	114 100	131 400	176 000	189 703	145 805	220 355	343 434	511 735	639 660	497 865	463 821	724 957	848 431	672 067	811 990

1/ Source: FAO yearbooks of fisheries statistics and national statistical reports
2/ Includes only selected species of commercial value that can be found in the Patagonian Shelf area and beyond 200 n.miles from the coast

Total catch of selected species by country in the South-West Atlantic, years 1970-85 [1/] [2/]

Country	Total catch in mt															
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Argentina	98 300	105 200	116 500	169 200	183 200	127 740	195 575	287 982	422 111	476 570	305 206	256 680	348 703	304 954	225 943	308 340
Bulgaria	-	-	-	-	-	-	-	858	-	-	-	-	-	-	10 031	17 172
Cuba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56	4 552
Germany, D.R.	-	-	-	-	-	-	-	-	10	414	25	-	-	414	8 909	12 258
Germany, FR.	-	-	4 000	-	-	-	-	-	8 841	4 717	-	-	-	-	-	-
Japan	500	100	200	100	3	219	861	128	18 328	19 848	11 046	20 196	36 974	28 341	67 527	90 249
Korea, Rep.	-	-	-	-	-	-	13	207	172	110	13	18	77	90	1 212	10 762
Poland	-	-	-	-	-	-	-	2 059	17 021	72 803	90 554	72 981	247 132	347 837	218 698	189499
Spain	-	-	-	-	-	-	-	-	-	-	-	-	-	16 000	13 000	9 200
Uruguay	5 600	5 700	10 600	6 400	4 000	13 457	15 464	25 096	45 252	63 032	64 605	96 749	73 520	85 471	69 592	99 863
USSR	1 800	3 100	100	-	2 500	4 389	8 442	27 104	-	2 166	26 416	17 197	18 551	65 324	57 099	70 095
Total	106 200	114 100	131 400	176 000	189 703	145 805	220 355	343 434	511 735	639 660	497 865	463 821	724 957	848 431	672 067	811 990

1/ Source: FAO Yearbook of Fisheries Statistics and National Statistical Reports

2/ Includes only selected species that are caught in the Patagonian area and beyond 200 n.miles from the coast. Catches of tuna-like and highly migratory species are not included. Totals represent more than 99% of global catches reported in the area

Table 4

Estimations of fishing effort in the South West Atlantic, years 1975-85

Years	Total fishing effort of trawlers (hours fishing)	Total fishing effort of Polish trawlers and jiggers (days fishing)	Estimated total fishing effort directed to southern blue whiting [1/] (days fishing)	Estimates total fishing effort directed to the short fin squid	
				(hours fishing) [2/]	(days fishing) [3/]
1975	407	-	-	-	-
1976	660	-	-	-	-
1977	206	-	-	-	-
1978	5 614	931	892	37 488	6 410
1979	8 920	2 865	2 026	95 871	15 283
1980	16 462	4 163	3 001	58 445	5 156
1981	5 437	2 680	2 224	21 288	4 789
1982	9 919	8 201	3 819	69 216	9 658
1983	21 696	10 208	6 158	176 964	8 058
1984	33 452	7 836	3 109	150 703	9 594
1985	36 412	7 189	2 232	167 991	10 286

1/ Estimated from the total catch and the Polish cpue data

2/ Estimated from the estimated monthly total catch and the monthly cpue data of Japanese trawlers

3/ Estimated from the estimated total catch by month and the Polish monthly cpue data (corrected to exclude effort directed to blue whiting)

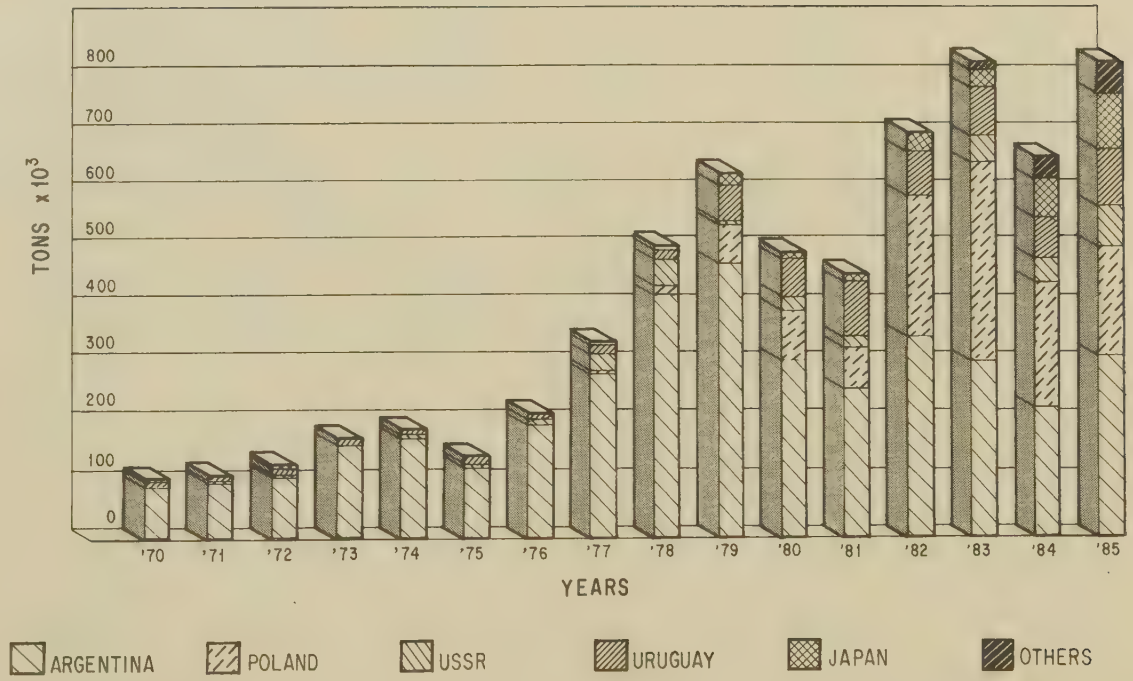

Figure 3 Total catch of selected species by countries in the South-West Atlantic, years 1970-85

offshore Patagonian Shelf area around the Falkland Islands (Malvinas), where a limited fishery yielding from 10 to 15 thousand tons of hake, squid, blue whiting and other demersal fishes was being developed.

Uruguay operates off the River Plate basin, outside the area of interest for this study. However, 60 to 80% of the Uruguyan catches are common hake, which migrate seasonally between the River Plate area and the northern and central Patagonian Shelf area considered in this study.

Poland and Japan are the main foreign offshore fishing nations in the area. Japan mostly fish for squid during the first part of the year, while Poland tends to operate all year round fishing for squid from January-March through July-August and for southern blue whiting in other periods of the year. They both operate in the southern Patagonian Shelf, mostly around the Falkland Islands (Malvinas) and along the Patagonian Slope, while Poland eventually also operates farther south in the Burdwood Bank. In the last few years the combined catches of Poland and Japan represented between 86% (in 1982) and 72% (in 1985) of the total catches reported by all the offshore foreign fleets in the area. Estimates of the total fishing effort of these two countries are presented in Table 4 together with an estimate of total effort (by all fleets) directed to southern blue whiting and shortfin squid.

No detailed fishing effort data have been provided by any of the other offshore fishing nations in the area. However, analysis of the British surveillance data provided by MRAG (1986b and 1987) and reproduced in Figs. 4 to 11, give a good indication of the total fishing effort deployed each month, since September 1983, by each fishing country around the Falkland Islands (Malvinas).

It is noted that in the case of Japan and Poland, for which global fishing effort data for the whole area are available, the estimated fishing effort around the Falkland Islands (Malvinas) area represents a highly variable fraction of the total effort reported for the whole area, although both values tend to follow more or less the same seasonal trends (Figs. 4 and 5).

1.2 Main Fisheries

Four main fisheries are identified in the area. The hake fishery, mostly conducted closer to the coast and towards the northern Patagonian Shelf and off the River Plate basin by Argentina and Uruguay; the southern blue whiting fishery, mostly conducted by Poland and the Soviet Union offshore in the southern part of the Patagonian Shelf and Slope; and so far two distinguishable squid fisheries, the one for common squid (Loligo sp.) and the one for

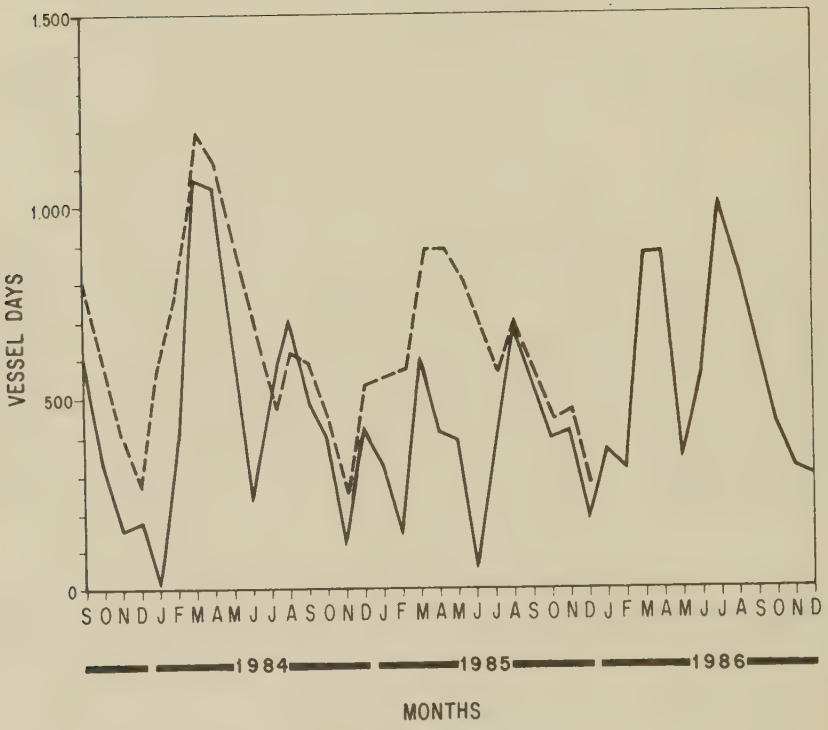

Figure 4 Total monthly Polish fishing effort in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 (solid line) estimated from British surveillance data by MRAG (1987), and total Polish fishing effort reported for the whole area (broken line)

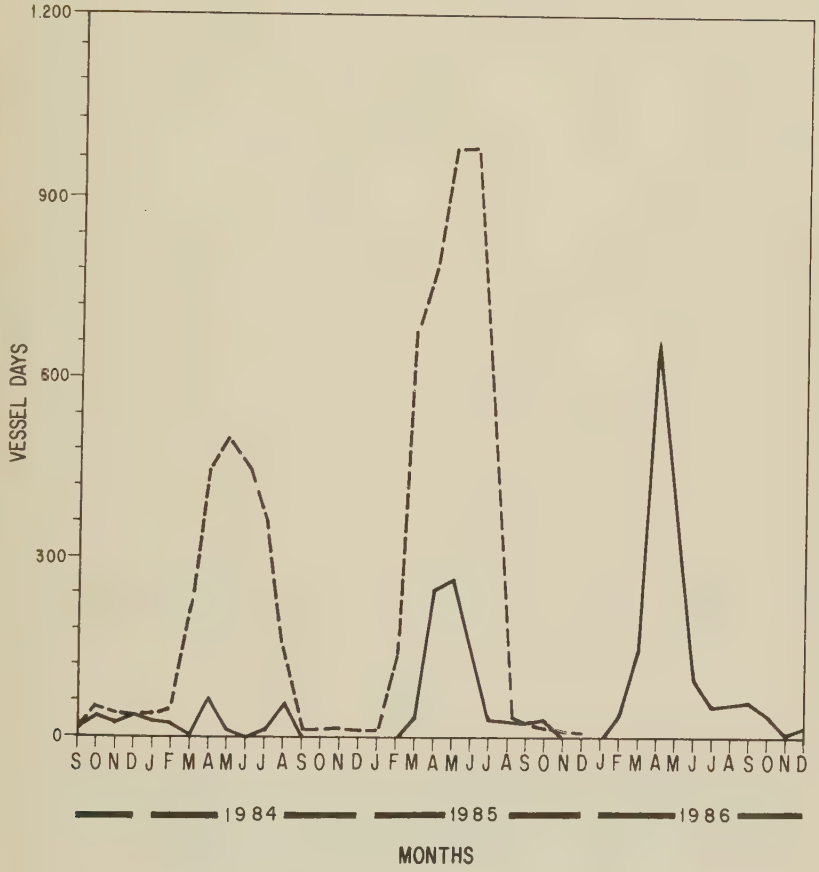

Figure 5 Total monthly Japanese fishing effort in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 (solid line) estimated from British surveillance data by MRAG (1987), and total Japanese fishing effort reported for the whole area (broken line)

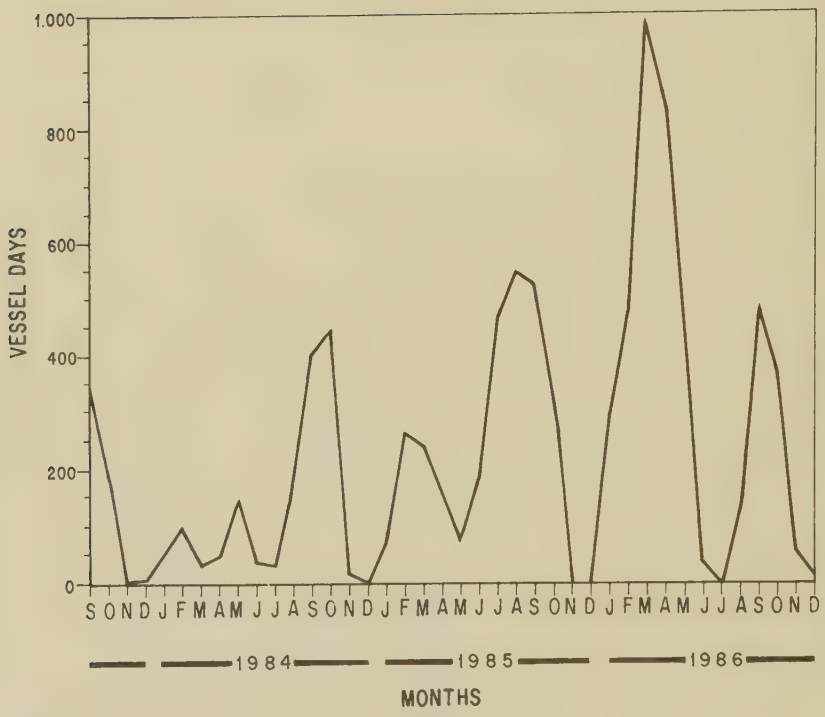

Figure 6 Total monthly Spanish fishing effort in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 estimated from British surveillance data by MRAG (1987)

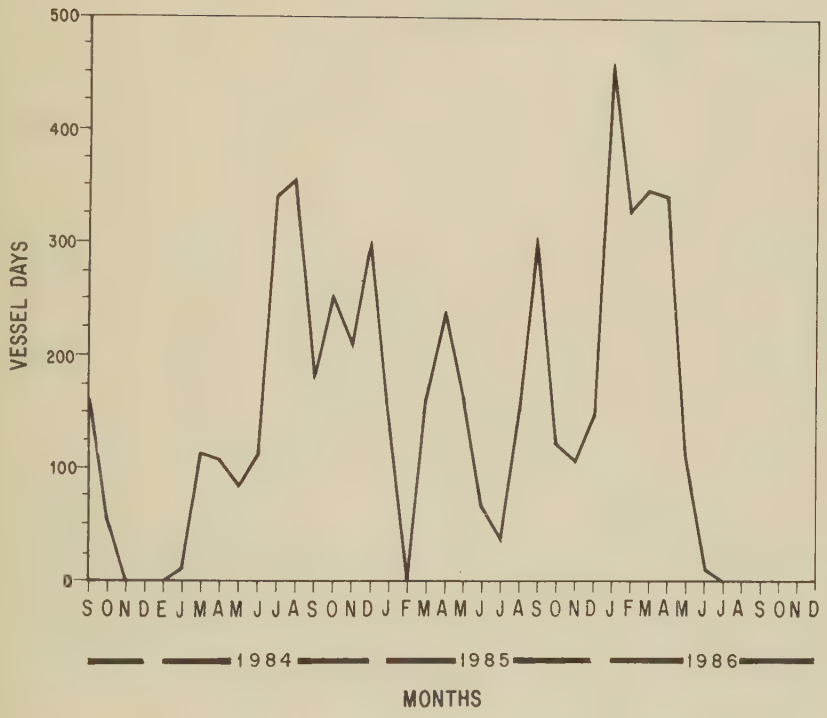

Figure 7 Total monthly U.S.S.R. fishing effort in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 estimated from British surveillance data by MRAG (1987)

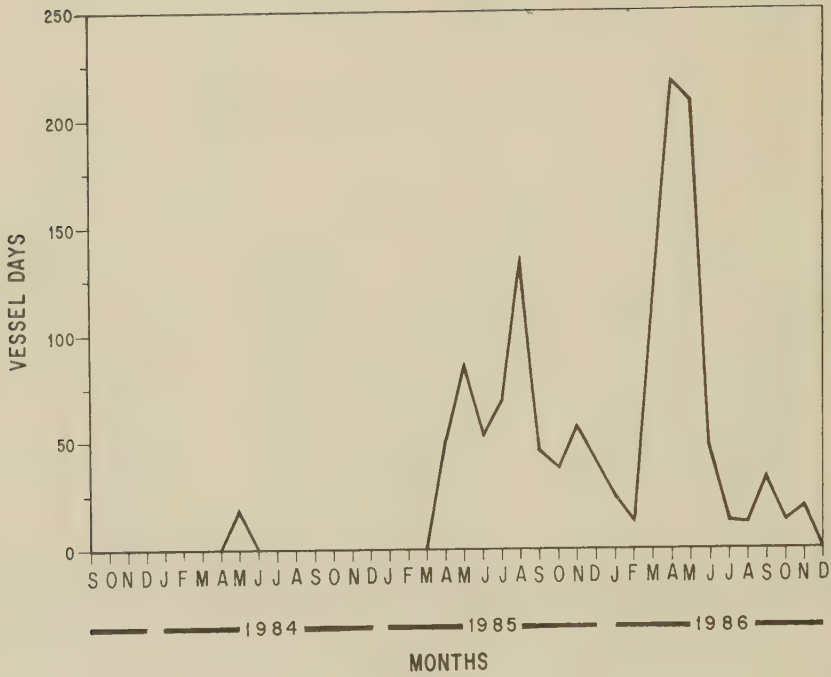

Figure 8 Total monthly fishing effort of the Republic of Korea in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 estimated from British surveillance data by MRAG (1987)

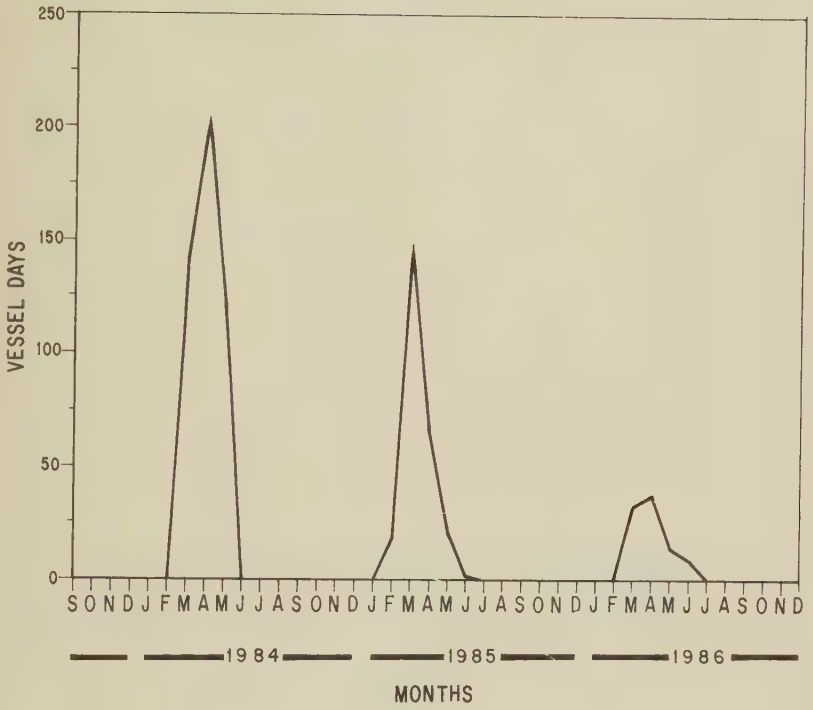

Figure 9 Total monthly fishing effort of the Germany Democratic Republic in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 estimated from British surveillance data by MRAG (1987)

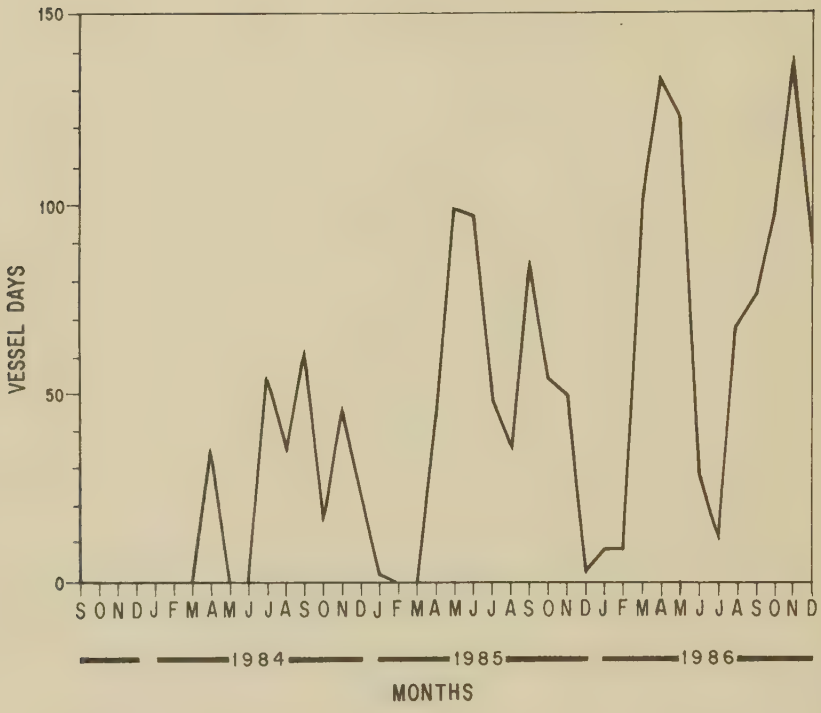

Figura 10 Total monthly Bulgarian fishing effort in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 estimated from British surveillance data by MRAG (1987)

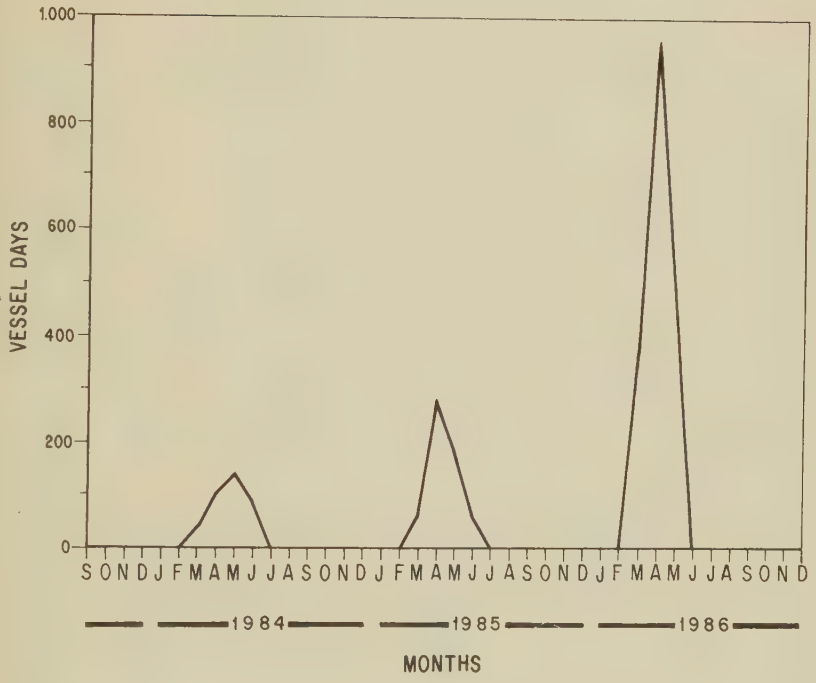

Figure 11 Total monthly fishing effort of other Asian fleets in the 150 miles around the Falkland Islands (Malvinas) between September 1983 - December 1986 estimated from British surveillance data by MRAG (1987)

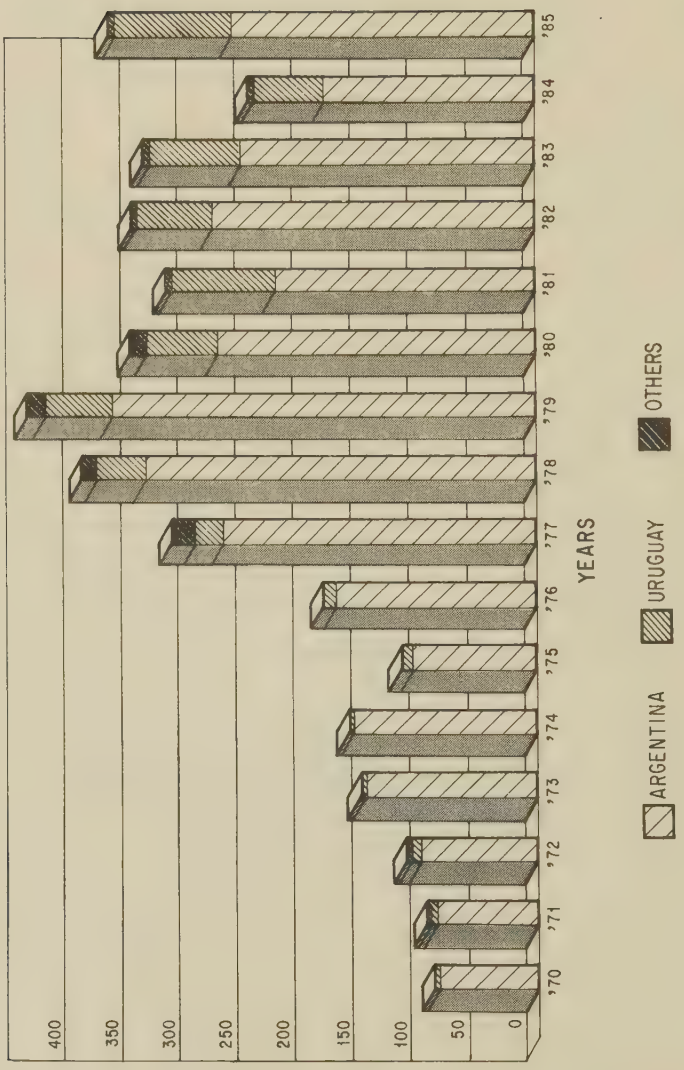

Figure 12 Total catches of hake (Merluccius spp.) by countries in the South-West Atlantic, years 1970-85

shortfin squid (Illex argentinus), both exploited in the southern Patagonian Shelf and along the Patagonian Slope by most nations operating in the area.

Most of the analyses in this report will concentrate on the two main offshore fisheries: the southern blue whiting fishery, and the shortfin squid fishery, for which enough original and detailed data have been provided by some of the countries fishing in the area.

The hake fishery mostly takes place within Argentinian and Uruguayan waters, where the two countries are actively involved in joint research programmes and management negotiations contemplated within the terms of reference of a bilateral treaty signed in 1973. Therefore no attempts would be made here to reassess the hake stocks and further comments in this respect will mostly rely on the results and biomass estimates already available.

With respect to the common squid it is unfortunate that very little is known about its biology, distribution and abundance, and that the fisheries data available is too scarce to allow any assessment for the time being.

Other fish resources are mostly exploited as by-catch or through occasional imprecisely directed fisheries, and there is no sampling or research programme directed on them. The available fishery data is therefore too limited to allow an assessment of these stocks although some comments could be made based on the current total catches and on the biomass and potential yield estimates available from past fishery resources surveys.

2. THE HAKE FISHERY

The hake fishery was the first one to develop in the area. Until the early '70s this resource was fished almost exclusively by Argentina (Fig. 12) which, at the beginning, operated within a short range from port off the River Plate basin and in the northern Patagonian Shelf area.

Hake catches by Uruguay were very small, and were also concentrated in the area off the River Plate basin. In the same years the Federal Republic of Germany, Japan and the Soviet Union operated occasionally in the southern part of the Patagonian Shelf and Slope reporting limited catches of hake, as well as of southern blue whiting, notothenids, squids, sharks and rays.

The Argentinian and Uruguayan hake fisheries continued to develop in the late '70s, newer and bigger vessels were brought in and the fisheries and the total fishing effort increased rapidly. In 1979 Argentina introduced some factory vessels to its fleet and started to

operate farther south and around the Falkland Islands (Malvinas), where they fished until 1982 catching between 5 and 10 thousand tons of hake per year.

Total catches of hake reached a maximum of 445 thousand tons in 1979, but dropped below 360 thousand tons in the following years. Rather than to biological causes this decline seems to be related to operational factors, such as relatively high operational costs and market constraints that affected mostly the Argentinian hake fishing industry.

The Argentinian and Uruguayan catches are almost entirely common hake (Merluccius hubbsi) that has a more coastal distribution in the area off the River Plate basin and the northern Patagonian Shelf. The Patagonian hake (M. polylepis) is usually found along the Patagonian Slope and around the Falkland Islands (Malvinas). Limited directed catches of Patagonian hake were carried out by Argentina between 1979 and 1982, and since 1978 have been fished only occasionally by Japan, the Soviet Union, Federal Republic of Germany, Poland, Bulgaria and Cuba. No directed fishery for Patagonian hake has been reported in recent years, although there are some indications that Spain might have done so in early 1983. Also, due to the great difficulties in distinguishing the two species through simple inspection, and the overlap in the areas of distribution, both the Patagonian hake and the common hake when caught offshore in the Southern Patagonian Shelf or Slope, are usually reported under a single general category as hake (Merluccius sp.). It is noted, however, that all Uruguayan catches, almost all Argentinian catches and an undefined proportion of other countries' catches reported in Table 2 as Merluccius sp. correspond to common hake (Merluccius hubbsi).

2.1 Assessment of the Hake Stocks

Besides a slight decrease in the total fishing effort and total catches, no major changes have been reported in the hake fishery since 1983. In that year the Ad hoc Working Group on Fishery Resources of the Patagonian Shelf (FAO, 1983) made a review of the available fisheries data and latest assessments of the common hake, and agreed that the Maximum Sustainable Yield of this stock was between 360 and 440 thousand tons/year as estimated by Otero and Verazay (1983). The Group also estimated that only between 2 and 6% of the total biomass of common hake could be found beyond the 200 nautical mile limit between 41°50'S and 48°S, where the catch rates are too low to encourage commercial fishing operations directed to this species.

The common hake stock is mostly distributed and exploited off the River Plate basin and in the northern part of the Patagonian Shelf area, within the Argentinian and Uruguayan Exclusive Economic Zones. The stock is considered to be moderately to fully exploited and management alternatives regarding this stock are discussed and could

be implemented under the terms of reference of the Joint Argentinian-Uruguayan Technical Commission for the Maritime Front (Comisión Técnica Mixta del Frente Marítimo).

Preliminary assessments of the Patagonian hake made on the basis of past research surveys are presented by Malaret et al. (1986). They estimated that the total biomass of Patagonian hake is in the range of 260 to 350 thousand tons with a potential yield of 50 thousand tons/year. No specific catches are reported for this species in the area, but judging from the "hake" catches reported by the fleets fishing offshore in the southern Patagonian Shelf area it seems that the catches of Patagonian hake are rather small, between 5 and 20 thousand tons/year.

Malaret et al. (1986) estimated that around 90% of the total biomass of Patagonian hake is distributed and could be exploited within a distance of 150 miles off the Falkland Islands (Malvinas). Using surveillance data MRAG (1986a, 1986b) estimated that in 1984 and 1985 the total catch of hake in this area was between 20 and 40 thousand tons/year, but according to the same source these figures might be an overestimation of the hake catches as some southern blue whiting might have been taken as hake in the estimation procedure.

Information on the Patagonian hake is very limited, but there is no directed fishery for this species and the results of past fishery resources surveys and the analyses of current catches and limited size/age data indicate that it is unlikely that this stock could be reaching its level of full exploitation. Therefore, for the time being there seems to be no urgent need to introduce management measures to protect this stock, although a sudden increment in overall fishing effort directed to this species might change the situation very rapidly, as might happen if just a fraction of the total fleet currently trawling for southern blue whiting and squid changes its fishing pattern and strategy and starts targeting on hake.

In addition to the level of exploitation, when considering possible management alternatives regarding the Patagonian hake, it may be worth also taking into account that the stock is mostly concentrated around the Falkland Islands (Malvinas), that its distribution area overlaps to some extent with the southern distribution of the common hake, that the two species are very difficult to distinguish by simple observation of external characteristics, thus making even the simplest catch statistics unreliable if not supported by adequate taxonomic studies, and last but not least, that it could be caught as a by-catch in other trawl fisheries, such as the ones directed to squid and southern blue whiting.

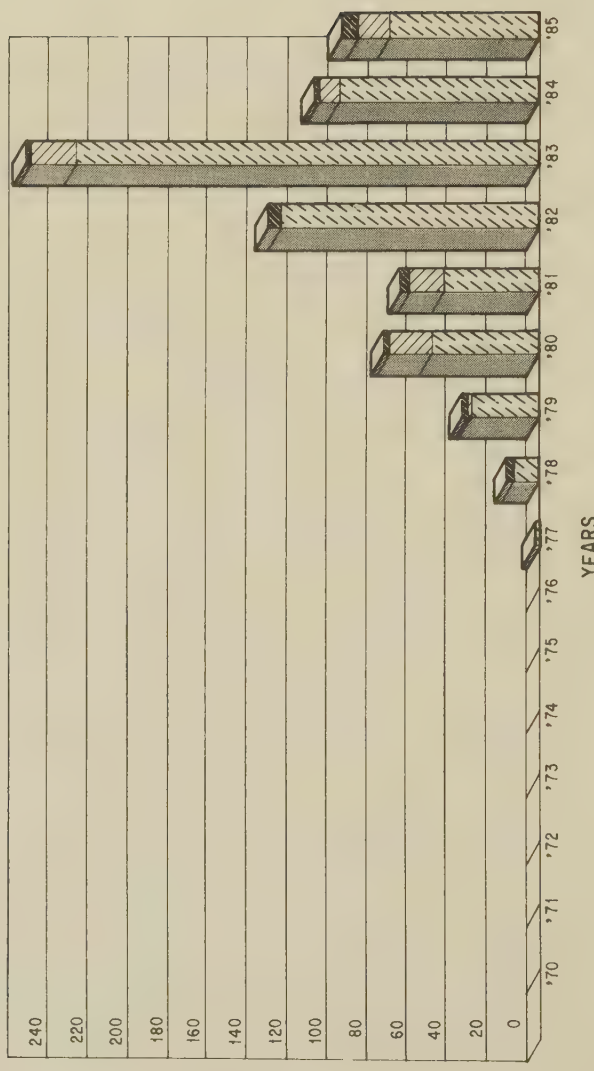

Figure 13 Total catches of southern blue whiting (Micromesistius australis) by countries in the South-West Atlantic, years 1970-85

3. THE SOUTHERN BLUE WHITING FISHERY

The southern blue whiting fishery started only in 1977-78 (Fig. 13) when a Polish long-range fleet started to operate in the area. Catches grew rapidly from 2 thousand tons in 1977 to about 260 thousand tons in 1983, and then dropped to 114 thousand and 97 thousand tons in 1984 and 1985 respectively.

The two main countries fishing for southern blue whiting are Poland and the Soviet Union. Polish catches (between 50 and 233 thousand tons/year in the last six years) represent between 70 and 95% of the total catch of southern blue whiting. The Soviet Union catches between 10 and 25 thousand tons/year, Argentina and Bulgaria have reported total catches of 2 to 5 thousand tons/year, and Japan reported 1 500 tons in 1985.

3.1 Observed Catch Rates

The initial catch rates when the fishery started in 1977-79 was less than 20 tons per fishing day, and increased steadily to 42 tons/fishing day in 1983, where it has remained more or less stable until 1985.

Figure 14 shows the catch rates (cpue) estimated from the Polish fleet data (Liwoch, 1986a) and Fig. 15 shows the estimated total fishing effort directed to the southern blue whiting since 1978. The increasing trend in cpue values between 1979 and 1983 seems to be reflecting the increase in the overall efficiency of the fleet associated with the "learning" phase (with improvements in the location of the best fishing grounds and overall fishing strategy) typical of the early years in a developing fishery. The stable cpue values in 1983-85 could reflect, in the best case, that the past fishing has not seriously affected the stock, although it might happen that a sensible reduction in the stock size be masked if there is a continued increase in the fishing efficiency. However, it is noted, that due to the long lifespan of these animals (that live up to 30 years) it may take some time before an identifiable response of the stock to fishing pressure is noticed.

3.2 Fishing Grounds

The main fishing grounds for southern blue whiting are located on the Patagonian Shelf and along the Slope, particularly around the Falkland Islands (Malvinas). Malaret *et al.* (1986) using data from past fishery resources surveys estimated that around 88% of the exploitable biomass of southern blue whiting was distributed within 150 miles of the Falkland Islands (Malvinas), and FAO (1983) using basically the same data source estimated that 1 to 12% of the exploitable biomass was distributed in the area of the Patagonian Shelf and Slope that falls beyond the 200 mile limit, between 41°50'S

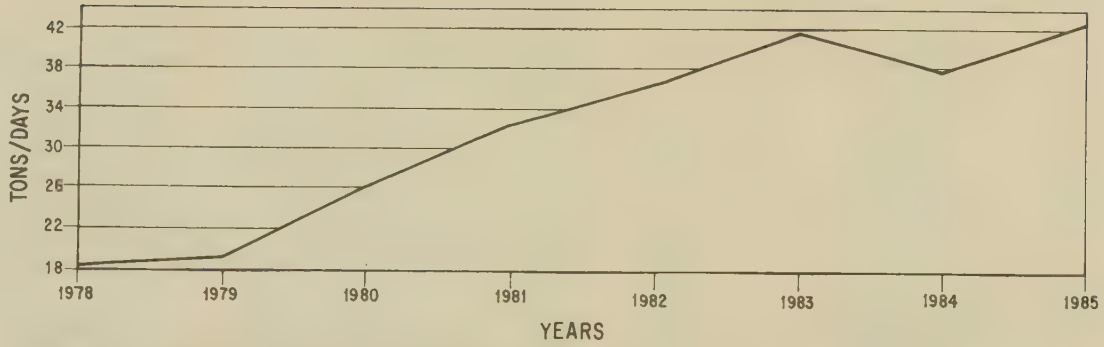

Figure 14 Catch per unit of effort (in tons per fishing days) of southern blue whiting (Micromesistius australis) in the South-West Atlantic, years 1978-85 (estimated from Polish catch and effort data)

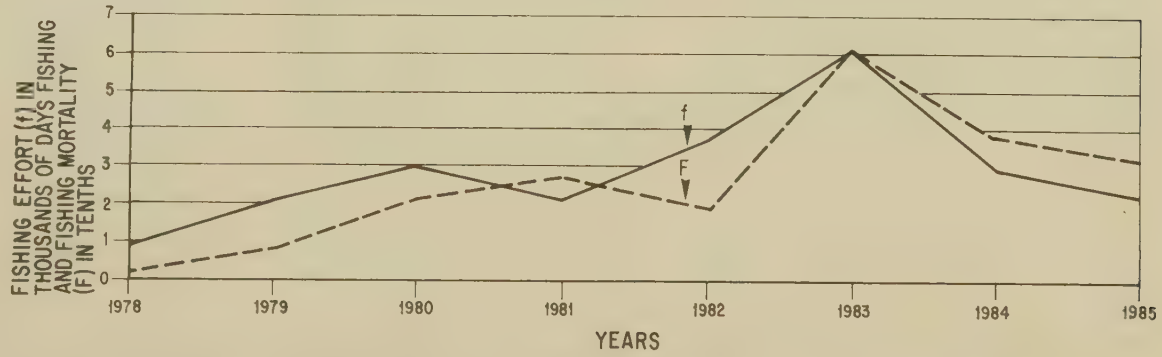

Figure 15 Total fishing effort (in thousand of fishing days) directed to southern blue whiting (Micromesistius australis) in the South-West Atlantic (solid line), and corresponding values of total annual fishing mortality (tenths of F, ages 15-22) estimated by VPA (broken line), years 1978-85

and 48°S. The stock is also distributed further inshore in the Patagonian Shelf and in the Burdwood Bank. The bathymetric distribution ranges from 50 to 900 m, with major concentrations at depths between 100 to 500 m, bottom temperatures of 4° to 8°C and salinities of 32.6 to 34.2°/oo (Inada and Nakamura, 1978; Perotta, 1982).

From 1977 to 1981, the main fishing ground (yielding around 95% of the total Polish catches) was in the eastern and northeastern part of the Falkland Islands (Malvinas), with a secondary and far less important fishing ground in the Burdwood Bank. In 1982 the main fishing ground shifted to the west and southwest of the Falkland Islands (Malvinas), and from 1983 onwards most of the Polish fleet fishing operations were conducted towards the southwest of the Islands, while the Soviet fleet apparently was mostly concentrated towards the south and southeast. Until 1982 the Polish fleet, and presumably also the Soviet fleet, was targeting on non-spawning concentrations while from 1983 onwards, an increasing proportion of the total catch was taken on spawning concentrations where catch rates are higher. It is estimated that in 1983 around 40% of the catches were made on spawning concentrations, while in 1984 and 1985 these proportions increased to 67-68%.

3.3 Biological Characteristics

Perotta (1982) reported that 50% of the southern blue whiting caught during fishery resource surveys in 1978 and 1979 were sexually mature at a total length of 34-36 cm and that 100% were mature at a total length of 48-50 cm. Liwoch (1986a) analyzed samples of the Polish catches in 1983 finding similar lengths at first maturity and reported that they corresponded to an age at 50% maturity (t_{m50}) of 3.5 and 4.5 years for males and females and to an age at 100% maturity (t_{m100}) of 9 and 10 years respectively. In addition, males and females are reported to have a similar growth curve until age 5 when the males growth slows down while females continue to grow until they reach a maximum length 7% greater than that of males. The parameters of the von Bertalanffy growth equations reported by Liwoch (1986a) are very similar to the ones reported in FAO (1983) and are as follows:

$$\text{Females: } L_t = 56.65 \text{ cm } (1-e^{-0.264(t+0.120)})$$

$$\text{Males: } L_t = 53.08 \text{ cm } (1-e^{-0.279(t+0.385)})$$

The age frequency distributions of southern blue whiting in the catches of 1981 through 1985 estimated on the basis of the Polish catch and age data provided by Liwoch (1986a) are shown in Figs. 18-22. In addition, Fig. 16 shows the age frequency distribution reported in 1973 by the Polish R/V "Professor Siedlecki", and Fig. 17 shows the age-frequency distribution for 1978 estimated on the

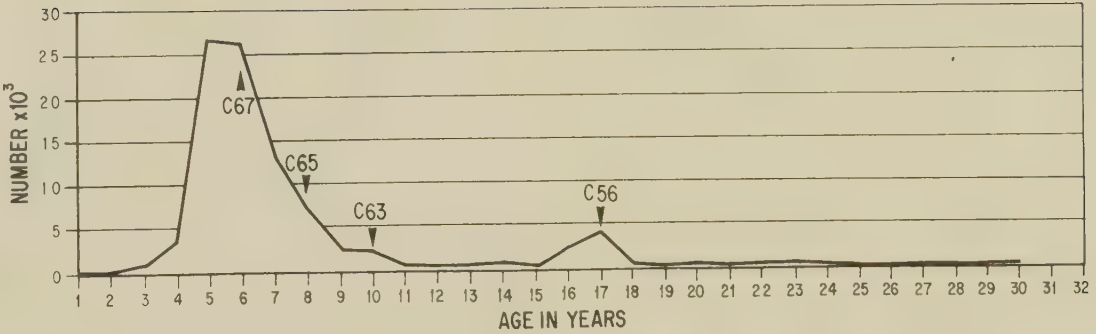

Figure 16 Age frequency distribution of southern blue whiting (Micromesistius australis) caught by the R/V "Prof. Siedlecki" in the South-West Atlantic in 1973 (from Zukowski and Liwoch, 1977)

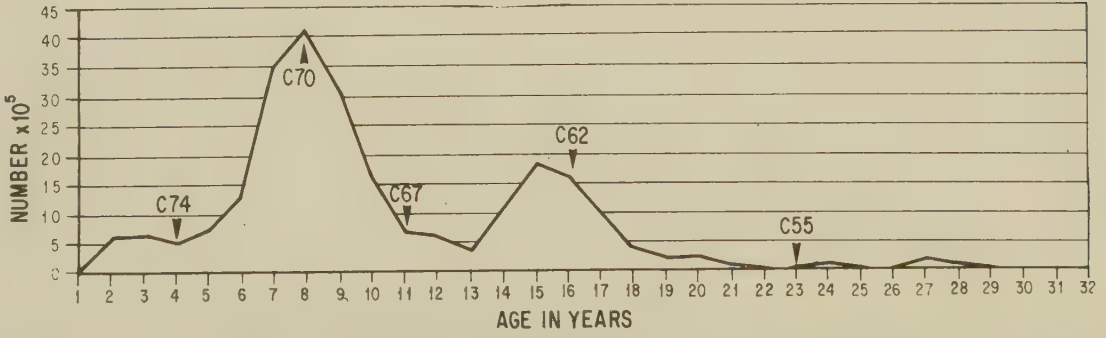

Figure 17 Age frequency distribution of southern blue whiting (Micromesistius australis) caught in the South-West Atlantic in 1978

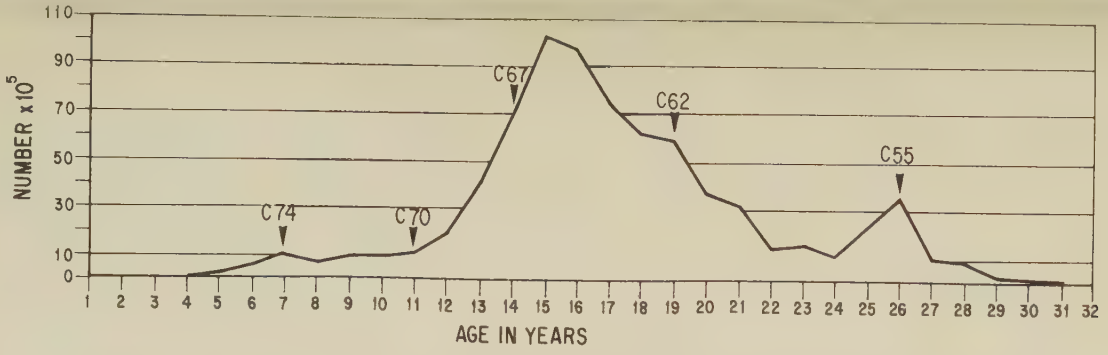

Figure 18 Age frequency distribution of southern blue whiting (Micromesistius australis) caught in the South-West Atlantic in 1981

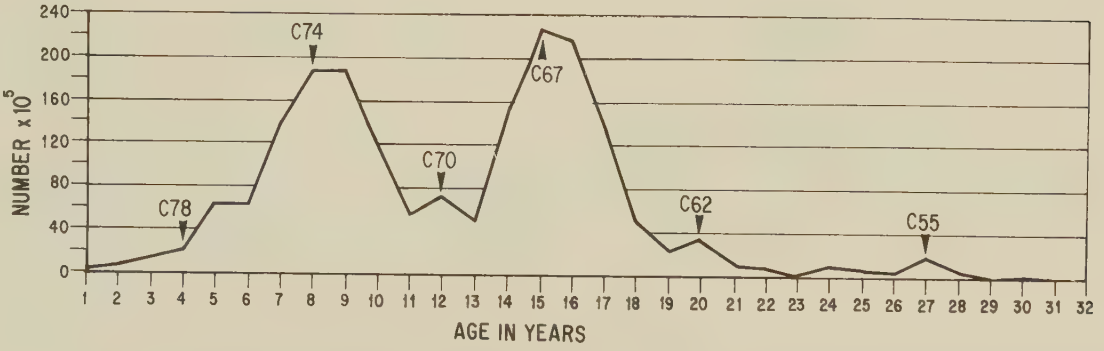

Figure 19 Age frequency distribution of southern blue whiting (Micromesistius australis) caught in the South-West Atlantic in 1982

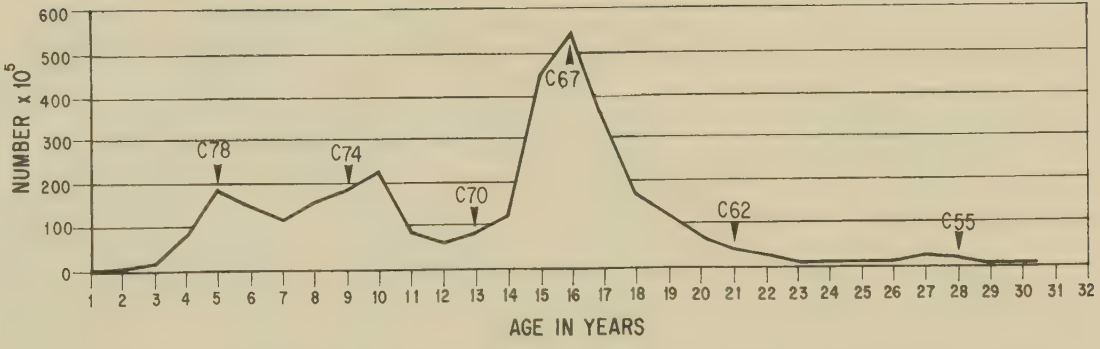

Figure 20 Age frequency distribution of southern blue whiting (Micromesistius australis) caught in the South-West Atlantic in 1983

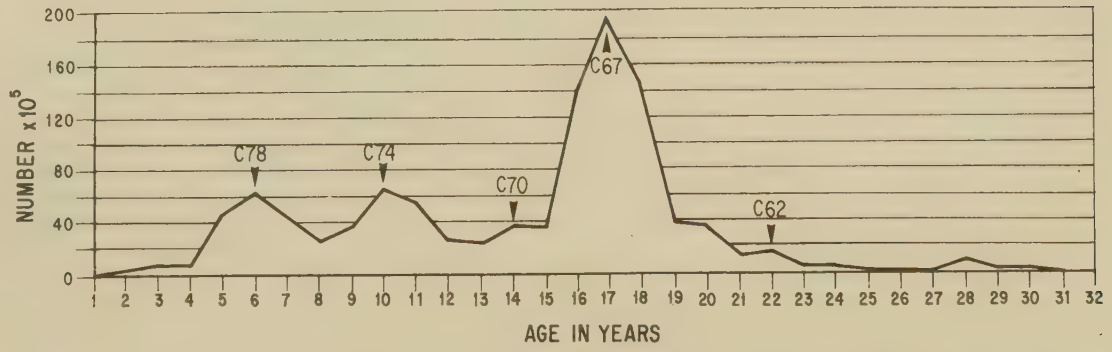

Figure 21 Age frequency distribution of southern blue whiting (Micromesistius australis) caught in the South-West Atlantic in 1984

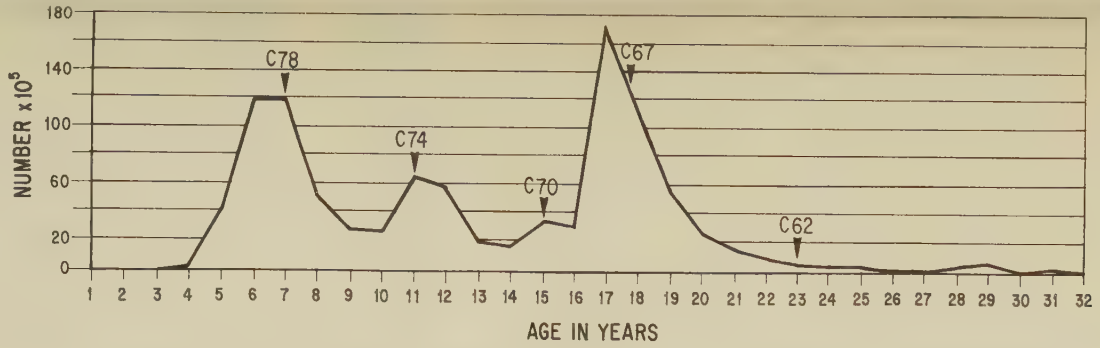

Figure 22 Age frequency distribution of southern blue whiting (Micromesistius australis) caught in the South-West Atlantic in 1985

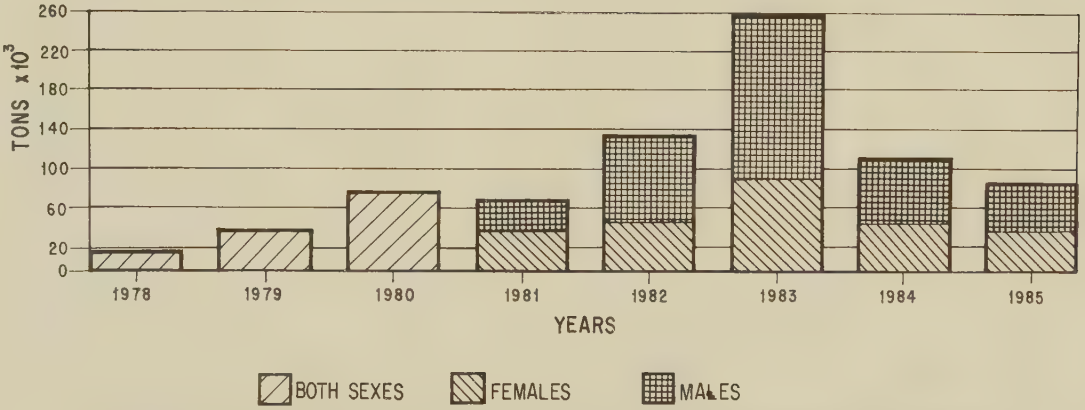

Figure 23 Total catch of southern blue whiting (Micromesistius australis) by sex in the South-West Atlantic, years 1978-85

basis of the length-frequency distributions reported by the Polish fishing vessels during that year and the age-length keys available for 1981-85. No adequate catch at age or length data are available for 1979 and 1980.

Most of the fish caught in recent years are mature and relatively old individuals. The age frequency distributions also suggest that there is a high variability in recruitment strength, with short successions of few very strong year classes, followed by a series of weak ones. This type of variability in the apparent abundance of successive age groups within the same year could also be caused by changes in catchability with age, but, nevertheless, changes in recruitment strength still seem to be the major cause of this variability since there are a few groups of the most abundant year classes that can actually be followed through several years as dominant year classes.

In the absence of any heavy fishing in the past (besides the high catches of notothenids reported by the Soviet Union in the 60's) it is reasonable to assume that most if not all of this variability has been caused by changes in environmental conditions. Some possible causes of this variability in the recruitment of blue whiting are suggested by Shpak and Kuchina (1983) who investigated the effects of the temperature and water circulation on the spawning efficiency of the same species in the New Zealand Plateau, and found that both the water temperature and the water circulation had a strong influence on the formation of spawning aggregations and on the survival of early life history stages.

At the time of this study no attempts were made to investigate the past trends and fluctuations in the environmental conditions in the area, and of the possible effects these may have on the fluctuations in recruitment strength of the southern blue whiting. This however is certainly a topic worth considering as part of any future research programme on this stock.

The available age frequency distributions indicate that during the last five years the fishery has been sustained by a few very strong age groups such as the ones belonging to the 1968, 1967, 1966 and 1965 year classes (with ages of 13, 14, 15, and 16 years respectively in 1981). These four year classes predominated in the catches until 1985 and could be traced back to 1973, where they also appeared as the most abundant year classes in the samples collected by the R/V "Professor Siedlecki" (Figs. 16 to 22). Other groups that stand out in the age frequency distributions are the 1970 year class, the 1973-74 year classes (ages 12 and 11 in 1985) and the 1978-79 year classes (ages 7 and 6 in 1985, Fig. 22), which hopefully will contribute to sustaining the fishery in the years to come as the older 1965-68 year classes are fished away.

In 1981 (no data available for previous years) both sexes were equally represented in the catch, although due to their bigger size females were 20% more abundant in weight (Fig. 23). In 1982 the sex ratio in the catches changed, and males were more abundant (male to female ratio 1.86:1.00 in weight and 1.92:1.00 in numbers). A similar sex ratio was observed in 1983, and the males to females ratio dropped slightly in 1984-85 (to 1.41:1.00 in weight and 1.67:1.00 in numbers). The same sex ratio was observed in all age groups in those years, except for 1983 when males and females were equally abundant in the younger age groups (ages 5 to 12), while in the older age groups males were far more abundant.

These differences in sex ratios in the catches can partially be explained on the basis of the differential sex and size/age bathymetric distribution reported by Perotta (1982) and the changes in fishing grounds reported by Liwoch (1976, 1976a). On the basis of research survey data, Perotta reported that males were more abundant at depths of 100-300 m, while females were more abundant in deeper waters. He also reported that younger individuals, and juveniles in particular, were mostly found in waters deeper than 200 m and in lower density concentrations. In fact, until 1981 most of the fishing was done towards the north and northeast of the Falkland Islands (Malvinas), where the Slope is steeper and, on average, depths are greater; while from 1982 onwards fishing was concentrated towards the southwest of the islands where the shelf is more ample and the waters are slightly shallower.

3.4 Resource Assessment

Several assessments of the total biomass of southern blue whiting have been made in the past using fishery resources survey data and the swept area method, and most of the results are reported together with the estimates of the total potential yield in Otero *et al.* (1982), FAO (1983) and Malaret *et al.* (1986).

These resources surveys were made between 1973 and 1982, when the southern blue whiting stock was virtually unexploited or was still very lightly exploited. The biomass estimates ranged from 400 thousand tons to 1.6 million tons depending on the vessel used and on the methods for stratifying and analysing the data. The long-term potential yields estimated on the basis of the above biomass estimates range from 72 thousand to 170 thousand tons/year.

Regarding these assessments based on trawl surveys and the swept area method is worth noting that the southern blue whiting has a semi-pelagic behaviour and performs extended seasonal and diurnal migrations into deeper waters. It is therefore likely that some if not all of these figures are underestimations of the total biomass and potential yield of the stock. This seems to be supported by the high cpue's (more than 40 tons/fishing day) and the high total catches

Table 5

Estimated total number (thousands) of southern blue whiting (Micromesistius australis) caught annually per age group in the South-West Atlantic, years 1978-85

Age	Year							
	1978	1979	1980	1981	1982	1983	1984	1985
1	52.	0.	0.	0.	365.	126.	10.	10.
2	600.	42.	0.	3.	667.	437.	355.	10.
3	616.	351.	84.	45.	1434.	1472.	666.	28.
4	472.	514.	708.	40.	2039.	7847.	749.	229.
5	708.	665.	1036.	177.	6280.	18324.	4586.	3878.
6	1278.	613.	1340.	521.	6275.	14396.	6263.	11924.
7	3467.	987.	1235.	999.	13847.	11247.	4290.	11900.
8	4114.	1977.	1988.	648.	18700.	15292.	2543.	5087.
9	3037.	2329.	3985.	904.	18665.	18225.	3573.	2826.
10	1576.	2244.	4693.	907.	11572.	22251.	6455.	2696.
11	668.	2517.	4521.	1038.	5412.	8283.	5515.	6522.
12	588.	3355.	5073.	1926.	7113.	5664.	2573.	5860.
13	329.	4916.	6760.	3992.	4849.	7988.	2237.	1903.
14	1085.	4521.	9905.	6753.	14944.	11730.	3619.	1713.
15	1804.	3854.	9109.	10286.	22524.	44484.	3452.	3499.
16	1566.	3623.	7767.	9671.	21740.	54020.	13857.	3001.
17	939.	3395.	7300.	7441.	13805.	33615.	19476.	17284.
18	343.	2096.	6841.	6210.	4972.	16937.	14481.	11365.
19	183.	1573.	4223.	5843.	2321.	11459.	3980.	5635.
20	201.	675.	3170.	3697.	3382.	6618.	3598.	2798.
21	57.	737.	1360.	3137.	991.	3732.	1456.	1455.
22	29.	456.	1484.	1310.	676.	2450.	1697.	977.
23	9.	1050.	919.	1428.	193.	662.	414.	436.
24	75.	1564.	2116.	952.	1000.	757.	488.	324.
25	34.	445.	3152.	2294.	622.	504.	137.	323.
26	30.	359.	896.	3451.	438.	547.	160.	46.
27	147.	77.	723.	908.	1788.	2402.	60.	78.
28+	65.	118.	393.	962.	778.	2040.	1302.	766.

obtained by the commercial fleet from a fraction of the population almost completely dominated by a few and relatively very old year classes, as well as by the analysis presented later in this report.

Due to the lack of fishery data suitable for stock assessment purposes, the assessments made in the past had to rely entirely on the results of fishery resources surveys conducted in the area before 1982. New data are now available, particularly from Poland, the main country fishing for this species, which will allow an assessment of the southern blue whiting stock using the Virtual Population Analysis (VPA) and a Thompson and Bell type of Yield per Recruit (Y/R) model.

3.4.1 Data base

The estimates of total catch in numbers at age were based on data from samples taken from the Polish commercial fishing vessels during 1978 and from 1981 through 1985 and provided as annual age-length keys for the main fishing seasons and the main fishing grounds by Liwoch (1986a). The samples were raised to the total Polish catches in each season and fishing area, and then to the total catch reported by all fleets in the South-West Atlantic. The assumption was made that all fleets fished the same size/ages as the Polish fleet. No catch at age or length data were available for 1979 and 1980 and the gap was filled by interpolation between 1978 and 1981. This was done by taking the weighed average of the 1978 and 1981 total catch at age distributions corrected for the change in age, and then raising this average to the total catch in the given year.

The full set of total catch at age data for the period 1978-85, with a 28+ age group (which includes data up to age 32) is presented in Table 5. No catch was reported at age 1 in 1984 and at ages 1 and 2 in 1985 and a dummy value, which will have no effect on the final results, was used for these two years and age groups.

The weight at age for these years was estimated from the age/length keys and the corresponding average weight at age also provided by Liwoch (1986a) for the years 1982-86 (Table 6). It was assumed that from 1978 through 1981 the weights at age were the same as in 1982. The maturity curve provided by Liwoch (1986a) was used to estimate the following fractions of mature fish at age used to estimate the equilibrium spawning stock biomass per recruit: 0.0 at and before age 3; 0.2 at age 4; 0.5 at age 5; 0.7 at age 6; 0.8 at age 7; 0.9 at ages 8 and 9; and 1.0 at age 10 and over.

3.4.2 Natural mortality

The data available allowed the application of several methods to estimate natural mortality (M) either directly or by estimating the

Table 6

Estimated average weight (kg) at age of southern blue whiting (*Micromesistius australis*) caught in the South West-Atlantic, years 1982-85

Age	Years			
	1982	1983	1984	1985
1	.046	.058	.034	.046
2	.099	.082	.117	.099
3	.241	.219	.250	.252
4	.325	.320	.346	.308
5	.455	.462	.450	.454
6	.552	.548	.535	.573
7	.628	.614	.623	.647
8	.713	.702	.701	.737
9	.772	.747	.746	.823
10	.833	.771	.815	.912
11	.874	.839	.880	.903
12	.930	.871	.937	.981
13	.950	.839	.981	.930
14	.981	.893	.995	1.053
15	.977	.886	1.112	.933
16	.980	.901	1.069	.971
17	1.001	.905	1.079	1.018
18	1.000	.920	1.043	1.037
19	1.022	.924	1.087	1.054
20	1.088	.954	1.205	1.102
21	1.104	1.150	1.146	1.015
22	1.101	1.022	1.182	1.099
23	1.193	1.064	1.313	1.202
24	1.062	1.002	1.152	1.032
25	1.071	1.005	1.148	1.060
26	1.070	.895	.905	1.410
27	.950	.861	1.120	.870
28+	1.000	.885	1.026	1.025

total mortality (Z) in the early years of the fishery, when M could be expected to be very close to Z.

The parameters available for this purpose are: maximum age, t_{max} = 32 years; age at first (50%) maturity, t_{m50} = 4 years; growth parameters of the von Bertalanffy equation, K = 0.27 and $L\infty$ = 54.9 cm; and average water temperature, T = 4°C. Values obtained ranged from M = 0.08, estimated from Fig. 58 of Garcia and Le Reste (1981) to M = 0.4 estimated with the equation of Rickhter and Efanov (1976). Intermediate values of Z ($\simeq$ M) = 0.13 and of M = 0.26 were obtained with the equations of Hoenig (1983) and Pauly (1981) respectively.

With respect to the various estimates of M it is worth noting that, contrary to what is usually observed in other species, the southern blue whiting seem to reach sexual maturity (at age 4) fairly early and has a growth rate (K = 0.27) which seems too high for a fish with such a long lifespan (maximum reported age = 32 years). That is why the estimates of M based on the observed maximum age are far lower (since they correspond to a long-lived animal) than the estimates based on the age at first maturity and the growth rate parameters (which correspond to a relatively shorter-lived animal). Since there are no independent estimates of M and the biological parameters used above are all well supported by the available data, an intermediate value of M = 0.2 was used as the most reasonable and logical choice. Since there is no indication that M might have changed with time or with age, the above value was used as a constant for all ages and years in the Virtual Population Analysis (VPA) and the Yield per Recruit (Y/R) analysis.

3.4.3 Results of the Virtual Population Analysis (VPA)

Several VPA runs were performed trying to smooth out the calculated F at age curve for each year while a reasonable agreement could be obtained between the calculated total fishing mortality and the yearly fishing effort.

The eight years and the 28 age groups from Table 5 were used in the analysis. The terminal values of F used in the final run for all ages in 1985 and the ages 27 and 28+ in all years are shown in Table 7 together with the calculated values of F for all the other years and ages. The annual estimates of F are plotted together with the corresponding values of effort in Fig. 15, and the estimated fishing patterns per year are represented by the plots of F at age in Fig. 24.

From this F at age pattern, it can be noted that fishing mortality is negligible in immature fish (up to age 4) and remains almost flat at low values (less than one-third of the full exploitation level) until age 15, when full exploitation starts. This type of fishing pattern certainly favours the conservation of the stock and

Table 7

Estimated fishing mortality (F) by age groups of southern blue whiting (Micromesistius australis) in the South-West Atlantic, years 1978-85

Age	Year								
	1978	1979	1980	1981	1982	1983	1984	1985	$\bar{F}$ 1983-85
1	.00020	.00000	.00000	.00000	.00087	.00030	.00002	.00002	.00011
2	.00364	.00019	.00000	.00000	.00075	.00127	.00104	.00002	.00078
3	.00321	.00261	.00047	.00008	.00129	.00202	.00238	.00010	.00150
4	.00127	.00328	.00646	.00028	.00427	.00865	.00126	.00100	.00363
5	.00164	.00220	.00812	.00198	.05418	.04815	.00622	.00800	.02079
6	.00782	.00173	.00542	.00502	.08963	.16902	.02081	.02000	.06994
7	.03065	.00744	.00428	.00496	.17774	.22916	.06955	.05000	.11624
8	.02588	.02192	.01853	.00275	.12053	.30358	.07405	.11000	.16254
9	.02539	.01830	.05609	.01044	.10172	.16531	.10709	.11000	.12747
10	.00333	.02348	.04650	.01617	.17872	.16929	.08107	.11000	.12012
11	.00154	.00654	.06024	.01294	.12624	.18760	.05761	.11000	.11840
12	.00202	.00947	.01627	.03285	.11525	.18652	.08168	.08000	.11673
13	.00209	.02086	.02370	.01589	.10817	.16315	.10560	.08000	.12292
14	.01077	.03569	.05326	.02970	.07606	.40934	.11804	.11000	.21246
15	.02715	.04810	.09355	.07192	.13074	.33663	.20139	.16000	.23267
16	.02826	.06989	.12906	.13591	.21304	.52241	.16570	.27000	.31937
17	.03037	.07893	.19557	.17562	.29192	.58995	.36048	.32000	.42348
18	.01549	.08769	.22495	.25388	.17043	.70237	.55036	.37000	.54091
19	.02034	.09139	.25480	.31101	.14177	.73045	.34821	.43000	.50288
20	.01792	.09702	.26771	.37069	.29254	.74499	.53437	.43000	.56979
21	.00784	.08433	.28761	.46205	.15948	.60816	.35556	.43000	.46457
22	.00121	.07987	.24314	.49589	.16873	.72830	.62504	.43000	.59445
23	.00032	.05514	.22836	.38973	.12347	.24790	.25217	.32000	.27336
24	.00681	.07031	.14993	.39122	.52270	.97006	.29186	.32000	.52730
25	.00532	.05078	.19696	.24063	.48074	.54828	.45454	.32000	.44094
26	.02426	.07131	.13680	.34309	.06579	1.06841	.33432	.27000	.55758
27	.02000	.08000	.20000	.20000	.30000	.60000	.30000	.27000	.39000
28+	.02000	.08000	.20000	.20000	.30000	.60000	.30000	.27000	.39000
$\bar{F}_{15-22}$	.019	.080	.212	.285	.196	.620	.393	.355	

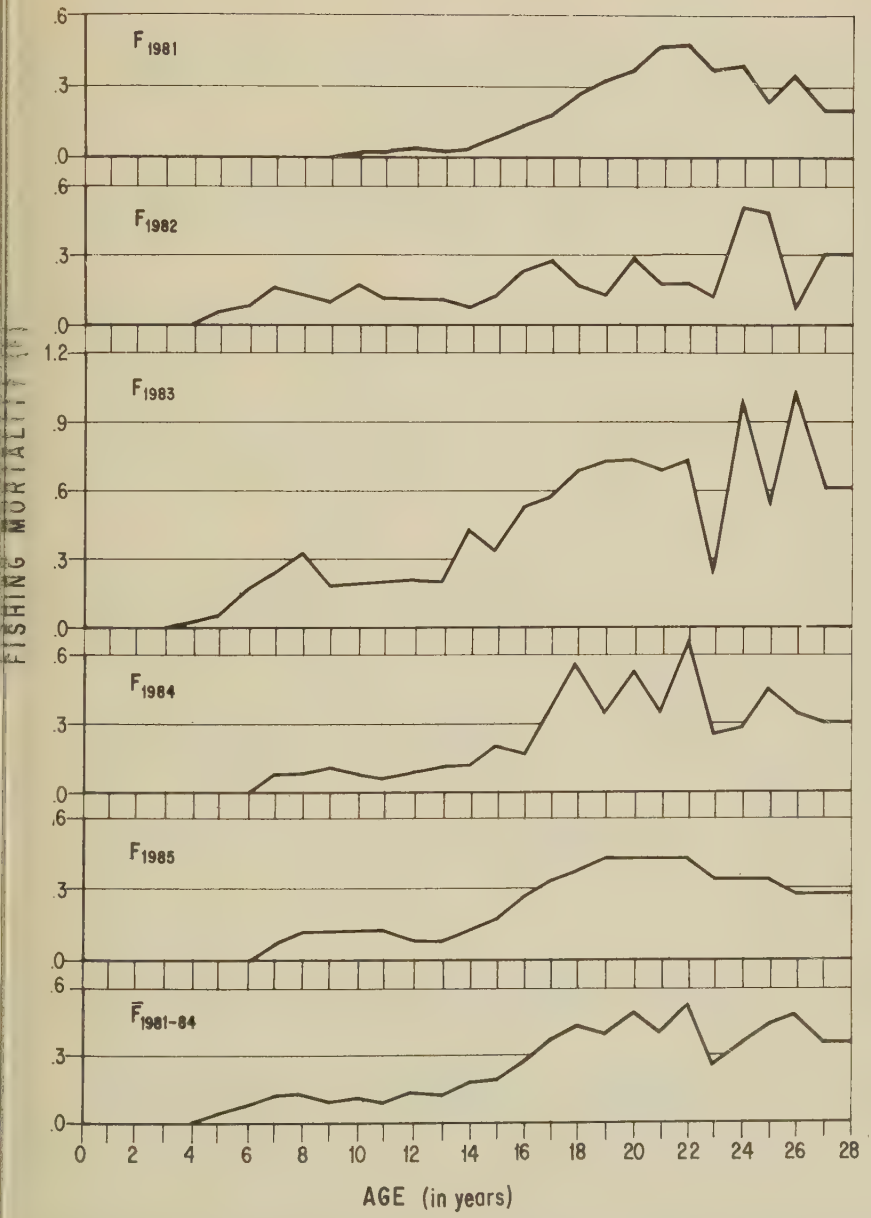

Figure 24 Fishing mortality (F) by age of southern blue whiting (Micromesistius australis) in the South-West Atlantic, years, 1981-85

Table 8

Estimated numbers at age (thousand) in the population of southern blue whiting (Micromesistius australis) in the South-West Atlantic, years 1978-85. The bottom lines show the estimated total biomass and spawning stock biomass (in tons)

Age	Year								
	1978	1979	1980	1981	1982	1983	1984	1985	$\bar{N}$ 1978-85
1	292614.	961005.	1834840.	1199744.	462692.	461513.	673823.	551671.	804738.
2	182120.	239525.	786805.	1502240.	982267.	378490.	377741.	551671.	625108.
3	212315.	148566.	196069.	644181.	1229927.	803610.	309487.	308948.	481638.
4	409207.	173272.	121318.	160452.	527370.	1005684.	656610.	252785.	413337.
5	478007.	334604.	141399.	98687.	131331.	429932.	816297.	536910.	370896.
6	180934.	390719.	273350.	114832.	80638.	101853.	335452.	664185.	267745.
7	126687.	146982.	319340.	222590.	93546.	60361.	70423.	268988.	163615.
8	177633.	100592.	119447.	260338.	181339.	64117.	39298.	53783.	124569.
9	133613.	141718.	80572.	96000.	212561.	131609.	38750.	29878.	108088.
10	522381.	106650.	113926.	62368.	77781.	157198.	91334.	28504.	145018.
11	480262.	426265.	85291.	89037.	50244.	53260.	108660.	68955.	170247.
12	321470.	392602.	346723.	65748.	71959.	36257.	36146.	83983.	169361.
13	174071.	262666.	318405.	279291.	52090.	52502.	24585.	27273.	148860.
14	111753.	142220.	210613.	254582.	225059.	36276.	35791.	18111.	129551.
15	74294.	90515.	112357.	163491.	202336.	170767.	20811.	26041.	107577.
16	61990.	59198.	70627.	83775.	124567.	145356.	99850.	13931.	82412.
17	34629.	49339.	45195.	50824.	59873.	82417.	70582.	69267.	57766.
18	24612.	27504.	37329.	30430.	34909.	36609.	37407.	40298.	33637.
19	10024.	19841.	20628.	24406.	19328.	24102.	14849.	17663.	18855.
20	12485.	8041.	14825.	13090.	14641.	13733.	9505.	8582.	11863.
21	8058.	10040.	5975.	9287.	7397.	8947.	5338.	4561.	7450.
22	26399.	6545.	7556.	3669.	4790.	5164.	3987.	3062.	7647.
23	31042.	21587.	4948.	4851.	1830.	3313.	2041.	1747.	8920.
24	12191.	25407.	16726.	3224.	2690.	1324.	2117.	1298.	8122.
25	7064.	9913.	19389.	11787.	1785.	1306.	411.	1294.	6619.
26	1381.	5753.	7714.	13037.	7587.	904.	618.	214.	4651.
27	8188.	1104.	4386.	5508.	7574.	5816.	254.	362.	4149.
28+	3621.	1691.	2384.	5836.	3295.	4939.	5515.	3556.	3855.
Total biomass	2596059.	2359863.	2186030.	2048567.	1977919.	1723959.	1578032.	1508656.	
Spawning stock	2229406.	2033689.	1812657.	1552294.	1341542.	1094906.	999878.	1011241.	

continuity of the fishery since, as far as a high proportion of the adult spawning stock (the younger ones) remains unexposed to fishing, it will be less likely that the stock will be driven into a recruitment overfishing or growth overfishing situation even if the fishing effort suddenly increases within reasonable levels.

Table 8 shows the estimated numbers at age in the population together with the estimated total biomass and the total spawning biomass for the years 1978-85.

The VPA estimates of total biomass and spawning stock biomass for 1978 (2.6 and 2.2 million tons respectively) are higher although within the same order of magnitude as the estimate of 1.6 million tons made by Japanese scientists in 1978-79 with the R/V "Shinkai Maru" and the estimate of 1.24 million tons made in 1978 by scientists of the Federal Republic of Germany with the R/V "Walter Herwig II". For 1981 the VPA estimates are still much higher than the estimate of 460 thousand tons made by Argentinian scientists the same year with the R/V "Dr. E.L. Holmberg".

There are certainly a number of weak points regarding the VPA estimates (such as the estimate of M and the relatively short data series that do not allow for adequate convergence) but at least, the results so far obtained are consistent with the available fisheries data and any discrepancies with the past resource surveys could be reasonably explained on the basis that, as noted before, it is likely that the past assessments are underestimations of the real abundance of the stock due to diurnal and seasonal migrations into deeper waters, the semi-pelagic behaviour of the species and the fact that not all age groups were equally available to the sampling gear. Also, what is most important, is that this preliminary VPA assessment provides estimates based on a relatively simple, generally well accepted and feasible way of analyzing the situation of an exploited fish stock using fisheries data, and the results can be improved every year as more data becomes available.

3.4.4 Equilibrium yield and biomass

A Thompson and Bell model was used to estimate the equilibrium yield per recruit (assuming an age at recruitment $t_r = 1$ year) and the spawning stock biomass for the exploitation pattern corresponding to the simple average of the 1983-85 fishing mortalities obtained by VPA. As in the VPA analysis, the average weights used were those from Table 6 and the natural mortality (M = 0.2) was assumed to be constant.

The estimated equilibrium yield curve for the present average exploitation pattern (Fig. 25) shows that the current fishing mortality (F = 0.46, for the ages 15-22) falls well below the conventional benchmark $F_{0.1}$ (= 0.76) and still further below the F_{max}

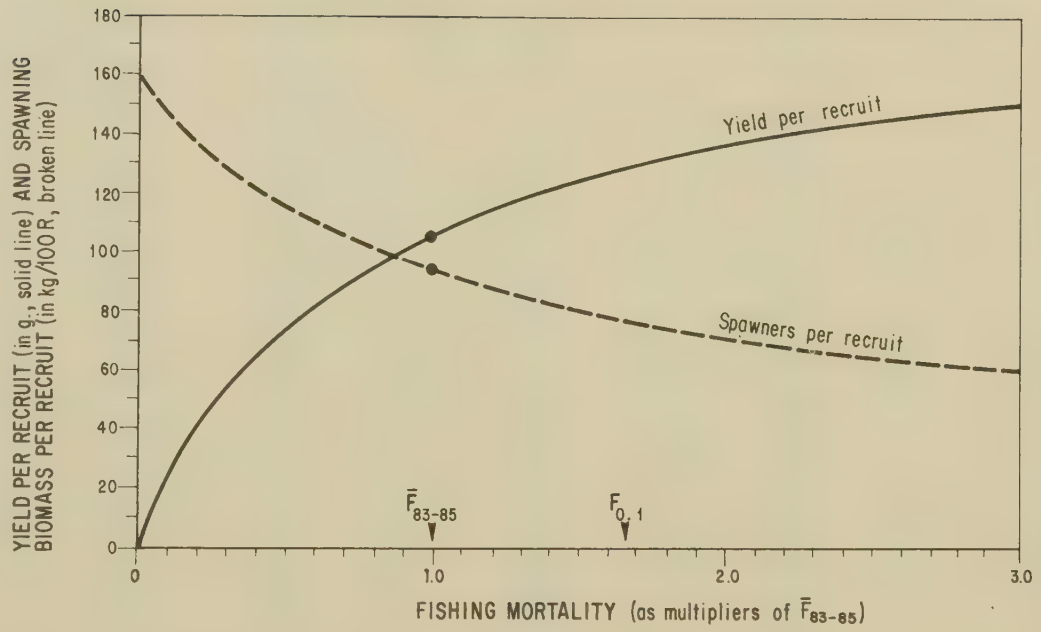

Figure 25 Yield per recruit and spawning biomass per recruit curves for the southern blue whiting (Micromesistius australis) in the South-West Atlantic

value, while the current yield per recruit (Y/R = 105 g) is about 80% of the one obtainable at $F_{0.1}$ and about 70% of the one obtainable at F_{max}. Also, the average equilibrium spawning stock biomass per recruit estimated for the same years, shows that under the current exploitation pattern and total fishing mortality the spawning stock biomass corresponds to 59.2% of the virgin spawning stock biomass.

The above analyses indicate that the stock is lightly to moderately exploited and suggest that as far as the same fishing pattern is maintained fishing effort could be safely increased to the level of 1983, which was 60% greater than the present average level (estimated as the average F for 1983-85). Under stable conditions it could be expected that this type of increase in fishing effort causes a 25 to 35% increase in the yield per recruit and a further 15 to 20% decrease in stock abundance.

Both the age frequency distribution in the catches and the population estimates made by VPA indicate that the fisheries have been sustained by a few strong year classes such as the particularly abundant 1966-68 year classes, that had been heavily fished in the past but still seem to be abundant enough to contribute to the total catches in the next couple of years.

One source of concern already pointed out by Liwoch (1986a) is that these three very strong year classes are not being followed by other year classes of comparable strength, although the 1973, 1974, 1979 and 1980 year classes seem to be relatively abundant and provide some hope for the future. Nevertheless, one should expect a certain decline in the total biomass of the stock which, at least in part, will be caused by relatively poor recruitments in the past. This certainly cannot be blamed on the fisheries but would have an effect on it by reducing the equilibrium yield and the catch rates beyond what they could be reduced to by fisheries alone.

This variability in past recruitments underlines the need for monitoring recruitment strength every year. A few very strong year classes have influenced the development of the fisheries in a positive way and by the same token a relatively long series of poor year classes would certainly have negative effects that could be prevented if the stock and the fishery are properly monitored and if steps are taken to apply adequate management measures when and if needed. For the time being, however, management measures do not seem to be urgently needed from a biological point of view or for conservation purposes, provided the overall fishing effort increases within reasonable limits and the fleet maintains the same fishing pattern. In this respect it should also be noted that most of the exploitable stock and the best fishing grounds are located around the Falkland Islands (Malvinas), where most of the current catches have been taken.

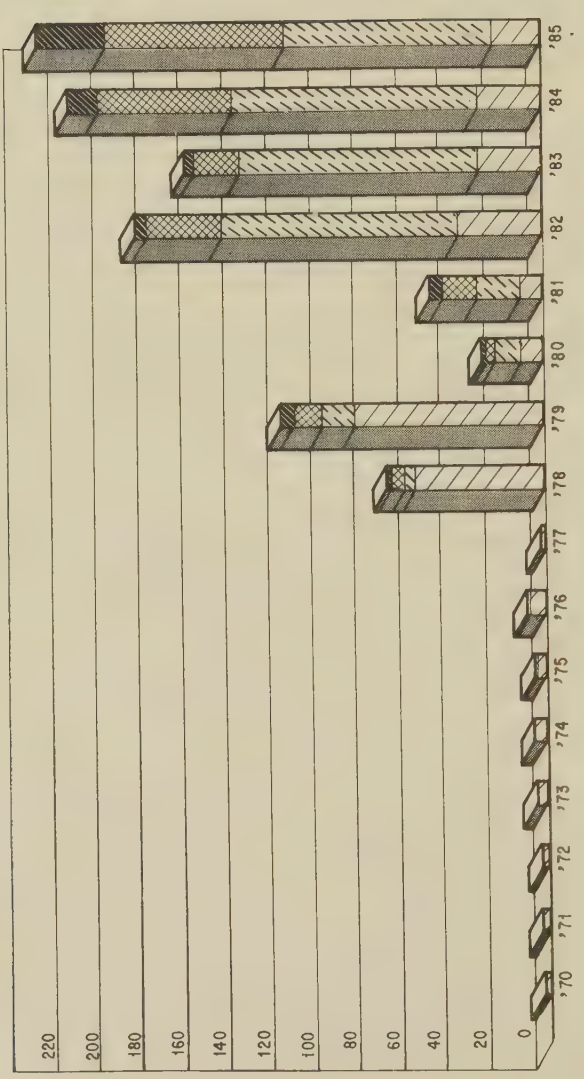

Figure 26 Total catches of shortfin squid (Illex argentinus) by country and by year in the South-West Atlantic, years 1970-85

4. THE SHORTFIN SQUID FISHERY

A small-scale fishery for shortfin squid was carried out by Argentina and Uruguay in the early '70s but catches were very low and were mostly limited to the area off the River Plate basin.

It was only in 1978 that a large-scale offshore fishery started, mostly through an increased fishing effort deployed by Argentina off the River Plate basin, the Patagonian Shelf and along the Slope. Other countries that also started exploiting this offshore fishery in 1978 were Poland and Japan. Catches rose from a few thousand tons a year to 73 thousand tons in 1978 and to 128 thousand tons in 1979 (of which 80% and 70% respectively corresponded to the Argentinian catches), but dropped in 1980 and 1981 to rise again in 1982 to a maximum catch of 234 thousand tons in 1985 with Poland and Japan appearing as the main fishing countries this time (Fig. 26). Other countries that participate in the shortfin fisheries are Bulgaria and the Germany Democratic Republic and more recently Cuba and the Republic of Korea.

4.1 Fishing Season and Monthly Catch Rates

The fishing season for shortfin squid usually starts in February-March, and lasts until June-July. Some limited fishing may however start as early as December and be extended throughout August-September, but in these months the total catches and catch rates are usually very low. Total catches by month for the total fleet (Fig. 27) have been estimated from the monthly catches reported by Argentina, Japan and Poland who, together, are reporting more than 90% of the total catches of shortfin squids in the area.

Two different estimates of fishing effort per month are possible from the reports provided by two of the main fishing countries. One expressed in total number of fishing days (Fig. 28), estimated from the catch rates of the Polish fleet (Fig. 29), which have been corrected to remove possible fishing effort directed to the southern blue whiting, and the other expressed in total number of fishing hours (Fig. 30) that have been estimated from the catch rates of the Japanese trawlers (Fig. 31).

The correction of the Polish cpue and effort data was needed only in some months in the years 1978-81 and was used to remove the effects of high catches of blue whiting on the overall cpue when the squid fishing season was starting or getting to an end. The basic assumption when correcting the Polish fishing effort was that most of the fleet would start and would continue fishing for shortfin squid as as long they were available, otherwise they would fish for blue whiting. It was also assumed that the fleet was always able to find high concentrations of blue whiting, with catch rates comparable to the ones obtained during the main blue whiting fishing season. Under

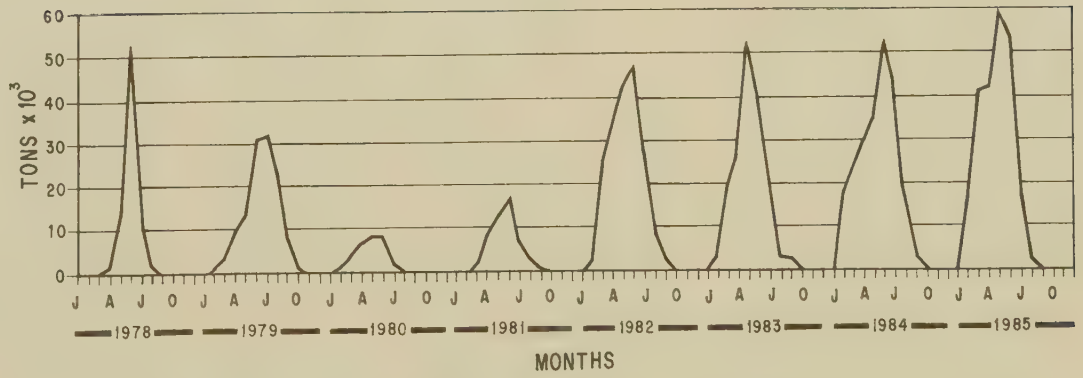

Figure 27 Total catch by month of shortfin squid (Illex argentinus) in the South-West Atlantic from January 1978 to December 1985

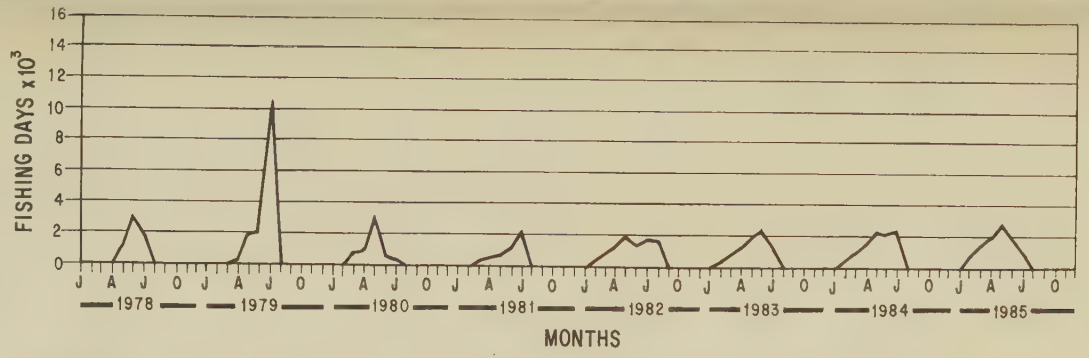

Figure 28 Total monthly fishing effort (in fishing days) directed at shortfin squid (Illex argentinus) in the South-West Atlantic estimated from Polish catch and effort data, January 1978 to December 1985

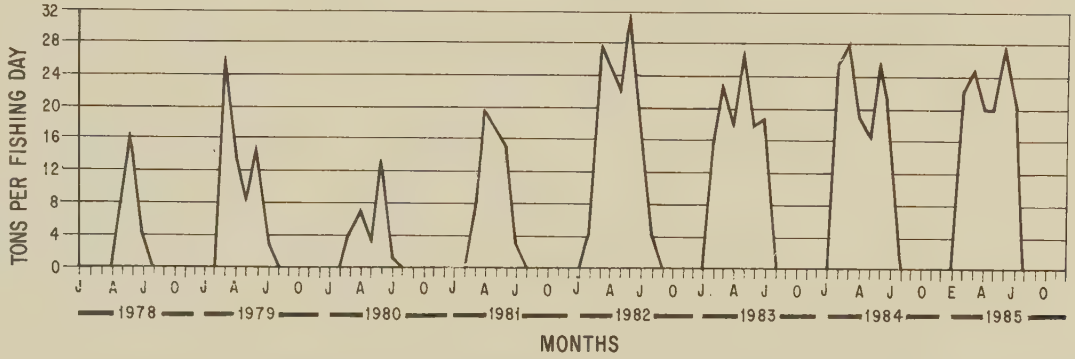

Figure 29 Abundance index by month (in tons/fishing days) of shortfin squid (Illex argentinus) in the South-West Atlantic, January 1978 to December 1985 (Polish cpue)

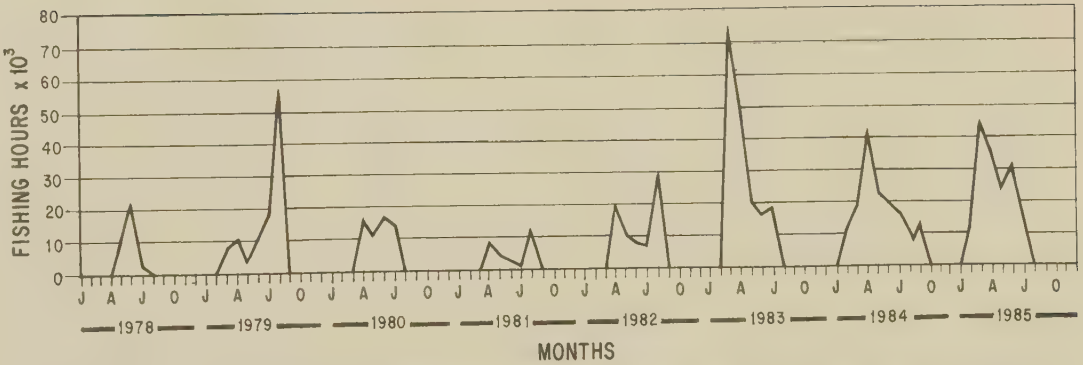

Figure 30 Total monthly fishing effort (in hours fishing) directed to shortfin squid (Illex argentinus) in the South-West Atlantic (estimated from the Japanese catch and effort data), January 1978 to December 1985

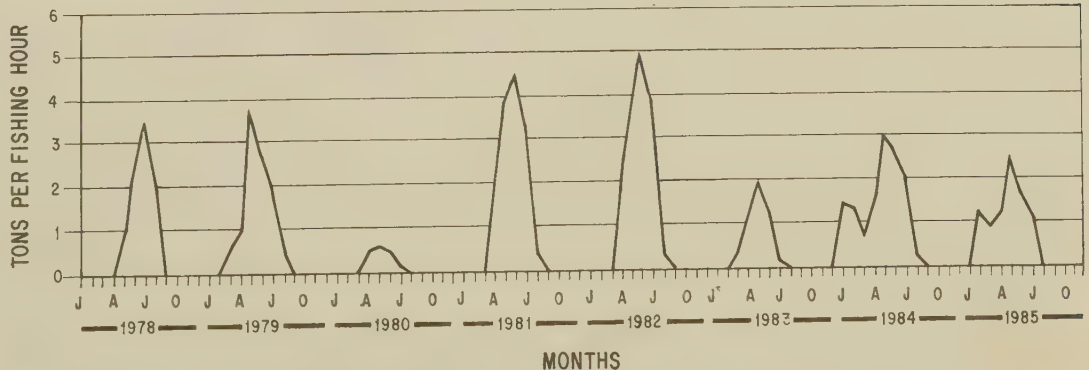

Figure 31 Abundance index by month (in tons/hours fishing) of shortfin squid (Illex argentinus) in the South-West Atlantic, January 1978 to December 1985

these assumptions, the monthly catches of blue whiting obtained during the fishing season were divided by the blue whiting average cpue and the fishing effort obtained was then subtracted from the total fishing effort in the month, leaving what was interpreted as the total fishing effort directed to squids.

4.2 Fishing Grounds

The distribution of shortfin squid covers almost the whole Patagonian Shelf and Slope at depths from 50 to 1 000 m. In early summer the shortfin squid is widely distributed on the continental shelf with sparse concentrations mostly closer inshore, and in autumn it starts to migrate offshore towards the continental slope where it forms high density concentrations corresponding to the fishing season. The stock then migrates farther offshore towards the outer continental slope and the oceanic waters where as reported by Liwoch (1976a), they die after spawning, causing the abundance to drop considerably over the entire region in late winter and spring.

Four main fishing grounds could be identified on the basis of this seasonal migration and the distribution of the fishing fleets: a) the area off the River Plate basin and the Northern Patagonian Shelf and Slope, which is the main fishing ground for the Argentinian and Uruguayan fleets and where the higher concentrations tend to occur in winter, although fairly good concentrations could also be found throughout the whole fishing season at depths between 200 and 800 m; b) the inshore Patagonian Shelf between 40° and 47°S, where catch rates tend to be low and some limited fishing is carried out by Argentina in late summer and early autumn; c) the offshore Patagonian Shelf and Slope area approximately between 42° and 48°S, where very high concentrations usually occur at depths of 200 to 800 m in late autumn and winter, and is exploited by all the offshore fleets fishing for squids in the area; and d) the Patagonian Shelf and Slope around the Falkland Islands (Malvinas), where very high concentrations also occur in the autumn, particularly towards the north and northeast of the Islands and is also exploited by most of the offshore fishing fleets.

It is estimated that the last mentioned two offshore fishing grounds, the offshore Patagonian Shelf and Slope between 42° and 48°S and the Falkland Islands (Malvinas) area, have contributed about 80% of the total catches of shortfin squid in the last five years. Both areas may be equally productive in some years, but apparently higher total catches and catch rates are usually obtained on the Patagonian Shelf and Slope north of 48°S.

The Falkland Islands (Malvinas) area corresponds to the southern-most part of the total area of distribution of the shortfin squid. Therefore, while in normal and good years the catch rates and potential yield of this area remains high, these may tend to drop more

than in other areas in the "poor" years or whenever there is a displacement of colder Antarctic waters towards the north, thus causing the fishing season to be delayed and restricted in time in this area. This may have happened in 1986, for which detailed information is not yet available, and to a lesser extent in 1983 and 1985, when apparently the total catches and catch rates around the Islands were much lower than farther north.

In 1978 and 1979 the offshore squid fishery conducted mainly by Poland and Japan took place in both of the above mentioned fishing grounds although, as indicated in the charts published in FAO (1983), almost all the Japanese catches of shortfin squid were reported to come from the fishing grounds to the north of 48°S. In 1980-82 most of the offshore fishing was apparently concentrated in the offshore Patagonian Shelf and Slope area between 42° and 48°S, and from 1983 onwards the offshore fishing effort has been directed to both the Falkland Islands (Malvinas) area and the offshore Patagonian Shelf and Slope area between 42° and 48°S.

In 1984 and 1985 it seems that, very roughly, 45 to 50% of the total catches of shortfin squid were made in the offshore fishing grounds to the north of 48°S, 40 to 45% in the south of 48°S and 10 to 15% in the inshore and the northern Patagonian Shelf and off the River Plate basin areas.

4.3 Biological Characteristics

The main biological and life history characteristics relevant for the assessment and management of the shortfin squid are documented, amongst others, by Brunetti (1981), Otero et al. (1981), Coehlo (1985), Hatanaka et al., (1985), Hatanaka (1986) and Koronkiewicz (1986), who have investigated the life cycle, distribution and general biology of this species. Some general aspects of the biology, assessment and management of cephalopods that might be of interest in the case of the shortfin squid are also presented in Caddy (1983).

Shortfin squid is a short-lived and fast-growing animal. It attains full sexual maturity and spawns within a year and almost the entire population, mostly composed of a single cohort, dies after spawning. The main spawning season occurs in winter, apparently offshore, in oceanic waters. In some years there is a secondary and relatively very weak summer spawning that occurs in shallower waters on the Patagonian Shelf. The winter spawners reach a maximum average mantle length of 27-30 cm for the males and 34-35 cm for the females, with a maximum total weight of 1.8 kg when they are fully mature. The summer spawners, which are less abundant and contribute very little (apparently less than 1%) to the total annual catches in the area, reach a maximum size in the range of 16-25 cm of mantle length.

The winter spawners may start to be recruited as early as December, but due to their low density and more coastal distribution only start to be exploited commercially from February-March onwards, which is when the stock concentrates on the offshore Patagonian Shelf and along the Slope. By the end of winter most of the population (composed of a single cohort or year class) has moved to the spawning area, probably in oceanic waters, where they nearly all die massively shortly thereafter.

The growth curve of the shortfin squid tends to change from one year to another (Hatanaka et al., 1985), probably in relation to the availability of food and environmental conditions, but it usually tends to be linear in the period of direct interest to the fisheries (February-July). Several growth curves have been fitted for the shortfin squid and are reported in the literature. The last one available, fitted for the 1984 data by Koronkiewicz (1986) is expressed by the following equations:

Females: $L_t = 187.26 + 0.921\ t$, and

Males: $L_t = 186.78 + 0.866\ t$,

where L_t is the average total mantle length in mm and t is the age in days.

4.4 Resource Assessment

FAO (1983) summarised the results of several resources surveys made between 1978 and 1982, where the total biomass of shortfin squid was estimated using the swept area method. The biomass estimates ranged from 60 thousand tons to 1.3 million tons depending on the time, vessel, type of stratification procedure and the catchability coefficient used. In addition to reporting the absolute biomass estimates, FAO (1983) also estimated that during those fishery resource surveys, between 11 and 35% of the total biomass of shortfin squid was found in the offshore Patagonian Shelf and Slope area that extends beyond the 200 mile limit off the coastline, between $41^{o}50'S$ and $48^{o}S$.

Based on the results of the 1981 surveys, FAO (1983) also estimated a potential yield of 115 thousand tons which, due to the high variability of the stock, can only be used as a reference for that particular year. MRAG (1986b) made an assessment of the shortfin squid stock in 1985 using British surveillance data and some complementary information. They analyzed how catch rates varied with season and position to estimate recruitment, growth and total mortality, and although recognizing that their estimates have to be treated with some caution, concluded that for the range of M values used, the stock of shortfin squid seemed to be close to overfishing or overfished already. Two assessments were made by MRAG: one for the

Table 9

Estimated average weight (in kg) of the shortfin squid (Illex argentinus) caught in the South-West Atlantic, by month, April 1978 - September 1985 (data from Koronkiewicz, 1986)

Month	Average weight (kg)							
	1978	1979	1980	1981	1982	1983	1984	1985
December 1/	-	.109	.098	.108	.109	.107	.110	.109
January	-	.165	.165	.167	.165	.165	.127	.166
February	-	.241	.244	.241	.205	.241	.181	.244
March	-	.332	.334	.299	.275	.399	.367	.328
April	.458	.463	.452	.488	.440	.576	.512	.497
May	.621	.617	.673	.637	.514	.639	.680	.688
June	.851	.827	.803	.764	.655	.851	.851	.851
July	1.127	1.127	1.126	1.127	1.127	1.127	1.127	1.127
August	-	1.455	1.457	1.455	1.455	1.456	1.455	1.456
September	-	1.834	1.827	1.835	1.833	1.838	1.667	1.848

1/ previous year

Table 10

Estimated monthly catches in number (thousands) of shortfin squid (Illex argentinus) in the South-West Atlantic, April 1978 - September 1985

Month	Total catch in numbers (thousands)							
	1978	1979	1980	1981	1982	1983	1984	1985
December 1/	-	-	2 219	41	951	414	3 481	618
January	-	1 709	559	125	128	23 534	128 474	3 023
February	-	3 926	1 773	1 008	8 305	79 542	138 633	74 094
March	-	12 379	10 837	7 627	97 209	61 050	80 769	125 812
April	365	21 602	14 822	18 039	75 323	90 439	65 456	85 446
May	20 880	22 761	12 671	21 000	83 582	62 445	78 985	86 761
June	61 608	36 675	9 759	21 143	73 157	25 871	49 138	63 164
July	6 690	28 337	1 137	5 965	24 440	2 134	14 390	14 595
August	-	15 592	204	1 874	4 810	1 085	1 853	768
September	-	4 134	26	67	779	77	2	9

1/ previous year

fishing ground around latitude 46°S and the other for the fishing ground to the south of latitude 50°S, and found that the situation seemed to be more critical in the area around 46°S.

New data and additional information covering the period 1978-85 have been made available for this report, which are used for a more complete assessment of the shortfin squid stock in the whole area using the Virtual Population Analysis (VPA) on a monthly basis, and a Yield per Recruit (Y/R) model of the Thompson and Bell type. Some considerations will also be given to the variability of both recruitment and stock size over these years. Also, since there is no evidence of the existence of more than one identifiable, separate population, we will treat all the shortfin squid caught in the area of the South-West Atlantic under consideration as belonging to a single stock.

The analysis will also be concentrated on the winter spawners, which, as indicated before, probably represent more than 99% of the total commercial catches of the species in the area and are caught from December through September each year.

4.4.1 Data base

Catch data per month were provided by Poland for the period 1978-85, and by Argentina and Japan for the period 1979-85. The total catch data by month of these three countries were then used to estimate the catch by month of all fleets in the area on the basis of their reports of total annual catches (presented in Table 2). The estimated total catch by month in the area is presented in Fig. 27. The total catch (in tons) by month was then converted into catch in numbers using the monthly average weights of shortfin squids in the catches reported by Koronkiewicz (1986), except for July-September when the average weights were extrapolated from the growth equations presented in section 4.3.

The monthly average weights of shortfin squid in the catch are presented in Table 9, and the estimated total number of squids caught by month, which is the main source of data for the VPA analysis, is presented in Table 10.

The critical question of defining a value of natural mortality for the VPA and the Yield per Recruit analysis was dealt with in the following way: a natural monthly mortality rate of $M = 0.12$ was used for December to June inclusive and this value was raised to $M = 0.15$ for July, to $M = 0.18$ for August, and $M = 0.24$ for September to account for the decrease in biomass in the fishing grounds due to emigration towards the spawning grounds. These values do not take into account the massive post-spawning mortality that essentially occurs outside the fishing season and grounds. The value of $M = 0.12$ corresponds to the monthly value generated by the equation

Table 11

Estimated fishing mortality by month of shortfin squid (Illex argentinus) in the South-West Atlantic, years 1978-85

Month	Monthly fishing mortality by year							
	1978	1979	1980	1981	1982	1983	1984	1985
December[1/]	0	0	.014	0	.001	.001	.004	.001
January	0	.002	.004	.001	0	.046	.170	.004
February	0	.006	.014	.005	.011	.196	.256	.119
March	0	.023	.105	.042	.157	.208	.212	.276
April	.001	.046	.186	.120	.160	.486	.244	.279
May	.056	.057	.220	.183	.245	.666	.469	.459
June	.213	.113	.240	.259	.320	.584	.544	.647
July	.030	.112	.037	.101	.156	.078	.278	.276
August	0	.080	.008	.040	.040	.050	.050	.020
September	0	.080	.008	.040	.040	.050	.050	.020
Total	.300	.519	.836	.791	1.130	2.365	2.277	2.101

1/ previous year

Table 12

Estimated numbers (millions) in the population of shortfin squid (Illex argentinus) in the South-West Atlantic, by month, years 1978-85

Month	Number in the population (millions)							
	1978	1979	1980	1981	1982	1983	1984	1985
December[1/]	739.5	853.4	171.0	285.9	1 030.5	629.6	984.4	895.2
January	655.9	756.9	149.6	253.5	913.1	557.9	869.8	793.4
February	581.7	669.7	132.2	224.7	809.7	472.7	650.7	700.9
March	515.9	590.3	115.6	198.4	710.4	344.5	447.0	552.0
April	457.6	511.9	92.3	168.8	538.7	248.2	320.6	371.4
May	405.5	433.7	67.9	132.7	407.0	135.4	222.9	249.2
June	340.0	363.2	48.4	98.0	282.5	61.7	123.7	139.8
July	243.7	287.6	33.7	67.0	181.9	30.5	63.6	64.9
August	-	221.3	28.0	52.2	134.0	24.3	41.5	42.4
September	-	60.4	3.6	1.9	22.3	1.8	-	.1

1/ previous year

of Pauly (1981) using the growth and temperature parameters in the literature, which is the same as the lowest value used by MRAG (1986b) and the one used by Patterson (1986), while the value of M = 0.24 used in September corresponds to the highest value of M = 0.08 for ten days used by MRAG (1986b).

The validity of the above estimates of M is supported to a large extent by the current knowledge of the main features of the biology and life history of the shortfin squid and other species of squid. However the accuracy of the above values could be subject to discussion, and since this could have some influence on the assessments and other results, it is worth noting that possible underestimations of M would cause fishing mortality to be overestimated and stock size to be underestimated by VPA, while yield and spawning biomass would be underestimated by Y/R analysis. This may lead to more pessimistic assessments, while the opposite is to be expected if M is overestimated. If this would be the case, two general approaches seem possible in the absence of more precise estimates of M, one is caution in the use of the results, to be followed by the second alternative which is to promote further research to improve the information on natural mortality of shortfin squid.

4.4.2 Results of the Virtual Population Analysis (VPA)

Several VPA runs for modified values of terminal Fs were performed for all years until a reasonable agreement was obtained between the calculated fishing mortalities and the total fishing effort directed to this species, and between the estimates of total biomass and the Polish and Japanese cpue data. The estimated values of fishing mortalities by month are presented in Table 11, the estimated population size in numbers by month are presented in Table 12 and the estimated biomass by month is presented in Table 13.

Reasonable correlation coefficients were obtained after a few trials, between the estimated total fishing mortality and the two estimates of total fishing effort available in the peak months of the fishing season. With the total number of hours fishing (estimated from the Japanese cpue data) the correlation coefficient for the years 1978-85 was r = 0.90, and with the total number of fishing days (estimated from the Polish cpue data) the correlation coefficient for 1980-85 was r = 0.84, while the correlation coefficient between the two measures of fishing effort for 1980-85 was r = 0.83.

Estimates of numbers at recruitment and total biomass are also in acceptable agreement with the series of cpue, and as expected, the VPA estimates indicate that recruitment fluctuated widely between about 150 million squids in January 1980 and 900 million squids in January 1982 (Table 12), with abundant year classes in 1979, 1984 and 1985. The biomass estimates (Table 13) also suggest that the spawning

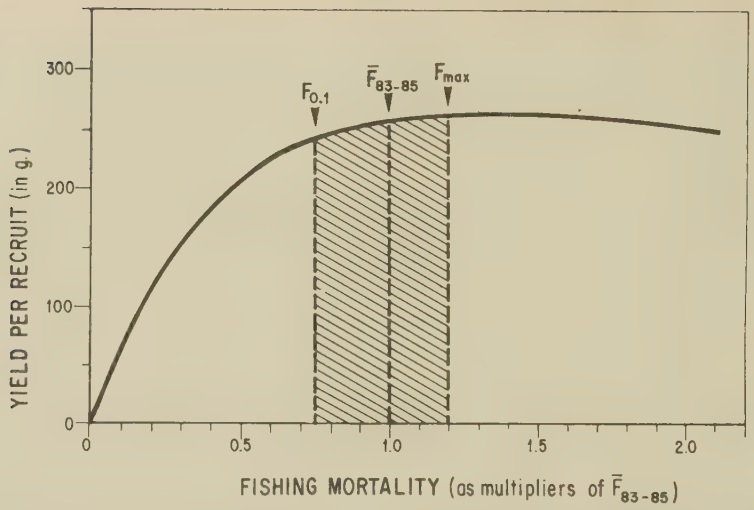

Figure 32 Yield per recruit curve of shortfin squid (Illex argentinus) for various levels of fishing mortality expressed as a multiple of the average 1983-85 value assuming the average 1983-85 fishing pattern prevails

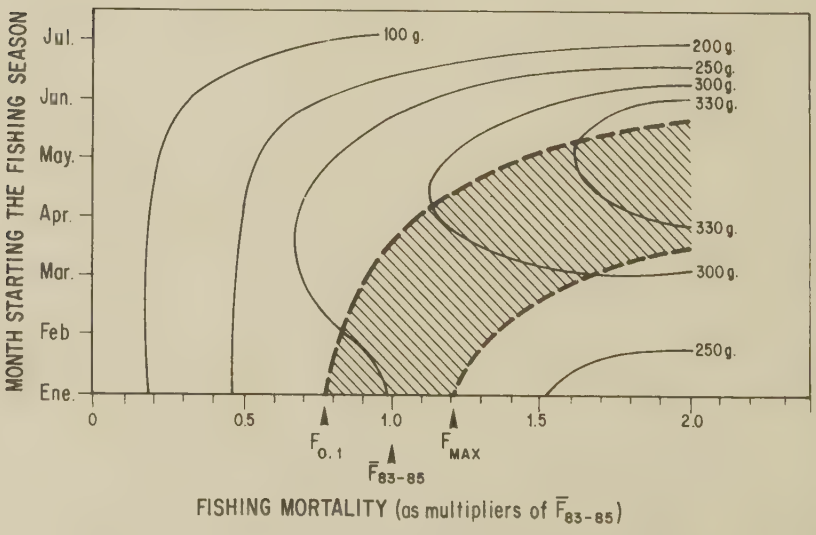

Figure 33 Isopleth diagram of the yield per recruit (in grams) for the shortfin squid (Illex argentinus)

stock biomass also had fluctuated widely over these years, from 35 thousand tons in July 1983 to 360 thousand tons in July 1979.

4.4.3 Yield per recruit

A Thompson and Bell model was used to estimate the yield per recruit for a range of values of total fishing mortality assuming a fishing pattern similar to the one of 1983-85 (calculated as the straight average of the 1983-85 monthly fishing mortalities obtained by VPA). The values of natural mortality and the average weights were the same as those used in the VPA.

The simple equilibrium yield curve in Fig. 32 shows that, for the present fishing pattern, the current fishing mortality ($\bar{F}_{83-85} = 2.24$) lies between the two generally accepted benchmarks of $F_{0.1}$ (which is 0.77 times the current value of F) and F_{max} (which is 1.18 times the current level of F) and produces a yield per recruit of Y/R = 251 g.

An isopleth diagram was then constructed by simulating the effects of delaying the start of the fishing season (Fig. 33). This was done by truncating the fishing pattern by artificially setting F = 0 in the months of closure. The shaded area in the diagram corresponds to the various combinations of fishing intensity between the two generally accepted levels of $F_{0.1}$ and F_{max} and the different starting dates of the fishery.

From the isopleth diagram it can be noted that since the fishing mortality is relatively low in December and January, delaying the start of the fishery to February causes very little difference in the equilibrium yield per recruit, as well as in the survival of the spawning stock (causing a 4% and an 8% increase in the two months respectively). With the same cumulative fishing mortality a further delay in the start of the fishing season until March gives a Y/R (=281g) higher only by 8%, although it may cause an increase of 21.8% in the surviving spawning biomass.

From these analyses, it seems that until 1985 the shortfin squid stock was reasonably exploited, and the same could probably be said for any combination of fishing mortalities and duration of the fishing season that falls within the shaded area in the isopleth diagram in Fig. 33. Any change in the overall fishing strategy that causes the point of F at date of start of the fishing season to move towards the lower right-hand side of the isopleth diagram (below the F_{max} line) will most likely drive the stock into an overfishing situation.

The fisheries data for 1986 are not yet available but the British surveillance data and other preliminary sparse information suggest that the cumulative fishing effort during the 1986 shortfin squid fishing season may have increased by at least 60% with respect to the

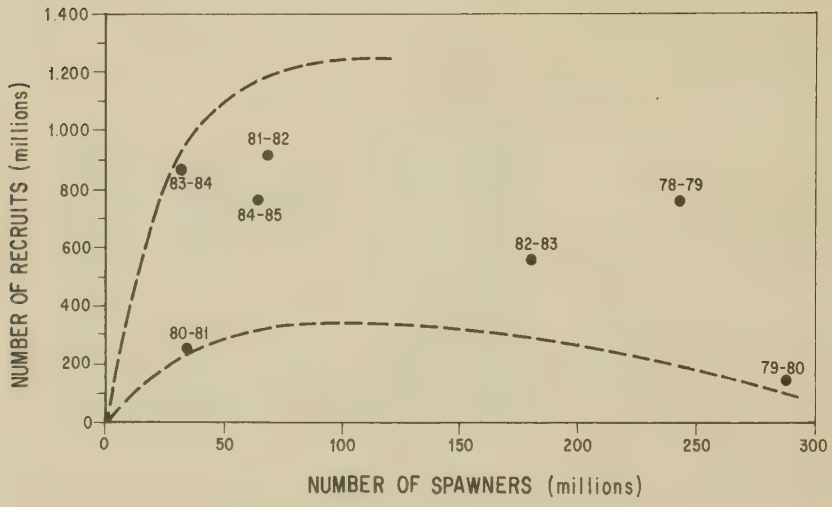

Figure 34 Relationship between the spawning stock of shortfin squid (Illex argentinus) in July and the recruitment produced in January the following year, years 1978-85

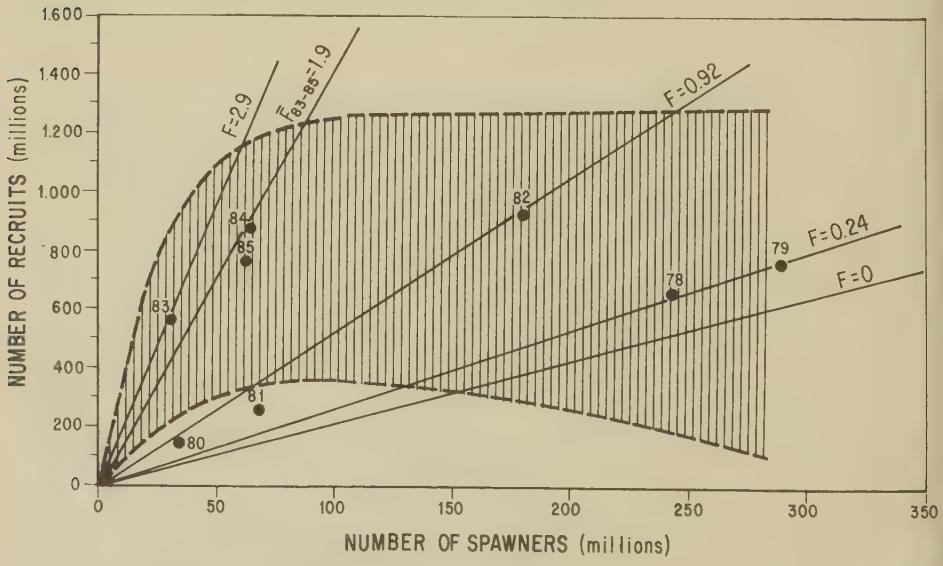

Figure 35 Relationship between the number of recruits of shortfin squid (Illex argentinus) in January, and surviving spawners in July the same year, years 1978-85

average level of 1983-85. If this is the case, and although there are also some indications that the duration of the fishing season was slightly shortened, it would indicate that the stock was overfished in 1986.

4.4.4 Spawning biomass and recruitment

A simple calculation of the ratio between the exploited spawning stock size and the expected virgin spawning stock size (where $S/S_{\infty} = \exp(-\sum F)$, assuming the same natural mortality for the exploited and non-exploited phase) would indicate that with the current level of cumulative fishing effort (average $F_{83-85} = 1.96$, from December through June inclusive) the escapement or surviving spawning stock was reduced to 14% of the expected virgin spawning stock size. This could raise some concern if compared with the arbitrary 40% escapement used as conservative reference level in the assessments of the shortfin squid made by MRAG (1986b) or if compared with the target exploitation rate of 40% used by some international commissions and suggested as a reasonably safe harvesting objective for managing squid stocks (ICNAF, 1978; NAFO, 1980; Caddy, 1983a).

For the range of values of cumulative natural mortality commonly used in the assessment of squid stocks (say, if cumulative M is between 0.75 and 1.3 during the exploited phase) the target exploitation rate of 40% is to a great degree comparable to the 40% spawning stock escapement mentioned above, and both are generally accepted, even if with some flexibility, as reasonable safe levels that reduce the risk of recruitment overfishing when there is no evidence of a possible stock recruitment relationship and the past history of the fishery provides no indication of the possible range of recruitment levels one can expect from various spawning stock sizes. The next step is to decide the extent to which this criteria should be applied in the case of the shortfin squid.

For this purpose the estimated number of squids in January each year (recruits) were plotted against the estimated number of squids (spawners) in July of the previous year (Fig. 34). While it would have been possible to fit one or more stock/recruitment curves, only two lines were drawn which correspond to the most likely upper and lower boundaries for the short but illustrative series of data points. If there should exist some kind of basic stock/recruitment relationship which is modified by the prevailing non-stock related (environmental) conditions, thus generating a family of stock/recruitment curves as suggested in Csirke (1980), the boundaries in Fig. 34 would correspond respectively to the outline of the highest and the lowest curves out of the possible family of stock (spawning)/recruitment survival curves for the shortfin squid in the period 1978-85.

It can be noted from this graph that the maximum and one of the minimum levels of spawning stocks are reported in two consecutive years (1979 and 1980), and both have generated similar and very low levels of recruitment when the stock was still very lightly exploited. Also, it is of interest to note that the two lowest levels of spawning stock recorded so far (in 1980 and 1983) have generated respectively one of the highest and one of the lowest values of recruitment, and that these two points fall in the boundaries that would correspond respectively to the best and to the worst environmental conditions affecting recruitment survival.

If, as it seems reasonable, future environmental conditions affecting recruitment survival can be expected to fall within the range so far observed, then a spawning stock size similar or slightly higher than the ones in 1980 and 1983 could be set as a benchmark for the minimum safe spawning stock level below which no fishing should be allowed. As suggested by the two boundaries in Fig. 34, any further decline in the spawning stock size below this level will most likely result in a proportional and steep reduction of the expected recruitment in the following year, which most likely will also generate a poor spawning stock, thus developing into a situation commonly defined as recruitment overfishing.

The area between the boundaries in Fig. 34 has been transferred as a shaded area to Fig. 35 where the estimated recruitment (stock in January) is plotted against the number of surviving spawners (stock in July) the same year. Replacement lines (that relate each recruitment to the surviving spawning stock) for different levels of exploitation are also plotted in Fig. 35. From this plot it seems that the 40% escapement (corresponding to the replacement line of F = 0.92) would lead to underexploitation of the stock (from the maximum yield point of view) whenever average or above average conditions occur, and would allow the surviving spawning stock to reach a size much bigger than the minimum needed to produce a similar range of recruitment values under the same possible range of environmental conditions.

In this case, the 40% survival or escapement seems a too conservative reference level for a wide range of expected values of recruitment, although it appears as a very reasonable safe level for the poor years, when recruitment is weak, as in 1980 and 1981. For instance, under average conditions the maximum equilibrium yield would probably be obtained with a 20 to 25% escapement (F between 1.6 and 1.4), but again, this cannot be set as a long-term equilibrium approach since it may mean overfishing the stock on poor years and probably underfishing it in the extremely good years.

Due to the strong environmentally influenced year-to-year variations in recruitment strength and the related high variability in

stock size, it does not seem possible to set a single constant level of fishing mortality or of fishing effort for the shortfin squid that will satisfy the objectives of maximizing the annual total yields and at the same time preventing overfishing and the eventual depletion of the resource and collapse of the fishery.

A criteria that could be applied in the case of the shortfin squid is the one proposed for other highly variable resources by McCall (1980) and in Csirke (1984), which allows the fishing to expand whenever the fish abundance increases (e.g., due to a strong year class) and tightens the protection in poor years, when recruitment is low. This can be done in the two following ways, which can complement each other:

a) by defining a minimum safety spawning stock size (e.g., minimum biomass or minimum cpue) below which the fishing season shall be ended. This minimum safety level could be somewhere between 1 and 1.5 times the average level of 1980 and 1983, which are the lowest spawning stocks recorded so far, and

b) by reducing the fishing mortality and fishing effort whenever a poor year class is detected, and allowing it to increase in the years when recruitment is strong. This may mean that in years with a poor recruitment such as in 1980 and 1981, the total fishing mortality and fishing effort may have to be reduced to 50% of the average 1983-85 level (this will allow a spawning stock escapement of about 40%), while in years when recruitment is high such as in 1982 and 1984, the fishing mortality and the fishing effort may be allowed to increase by as much as 30% with respect to the average 1983-85 level (this will allow a spawning stock escapement of around 8%).

It is noted that long-lasting increases in the overall fishing effort beyond the levels suggested above would lead in most cases to undesirable situations such as growth overfishing and/or recruitment overfishing. Due to its growth and seasonal distribution pattern there seems to be no great need to worry about growth overfishing in the case of the shortfin squid, but attention should be placed in preventing recruitment overfishing which is most likely to occur in view of the high recruitment variability and the high levels of fishing effort that apparently can be concentrated in the feeding and "pre-spawning" areas. If not prevented or corrected in time, recruitment overfishing may easily lead to a severe and long-lasting collapse of the stock and of the fisheries in the area.

Previous analyses indicate that at least until 1985 the stock of shortfin squid has been adequately exploited. From the point of view of maintaining the highest continued catches the stock has been

fully exploited since 1983 with total yields very close to the maximum attainable, while the spawning stock survival has been reduced to levels that so far do not seem to have placed the conservation of the stock in serious danger.

It should be added, however, that the ascertained risks of overfishing and stock collapse remain and have probably been augmented. In fact, these risks start and increase as fisheries develop and are certainly greater at the level of full exploitation than when the stocks are recognized to be slightly exploited or underexploited. They are also greater in highly variable resources, and when high levels of fishing intensity can be concentrated with relatively short notice in areas where fishery regulations can hardly be imposed. From this point of view it will be advisable to monitor the fishery, as far as possible on a monthly basis, to facilitate the timely adoption of management measures that might be needed if the overall fishing effort increases or if the spawning stock is reduced beyond the desirable levels.

In a dynamic fisheries of this kind, one priority will be to obtain an estimate of the recruitment strength as early as possible in the fishing season to, on that basis, regulate the total fishing effort in order to ensure an adequate spawning escapement that year. The other priority will be to monitor the abundance of the stock later in the season to guarantee that the spawning stock is not driven below the minimum safe level, and to take remedial action before that happens.

An early estimate of the recruitment strength could be possible by monitoring the cpue of the commercial fleet early in the fishing season or through fishery surveys or exploratory fishing before or at the beginning of the season. In this respect, it is worth mentioning that a good correlation was obtained for the years 1979-85 between the Polish cpue (catch per fishing day) in March and the recruitment estimated through VPA ($r = 0.85$ for the equation $R = 46.04 + 18.83$ cpue). This, however, is not surprising since both the Polish and the Japanese cpue and the estimated overall fishing efforts were used to tune up the VPA results. A poor correlation ($r = 0.41$) was however obtained between the estimated recruitment and the Japanese cpue early in the season.

Fishery surveys or exploratory fishing can probably be used to monitor the abundance of the spawning stock. However, the catch and effort data from the commercial fleet could also provide a reasonable and easiest way to obtain an index which can be used to effectively monitor the abundance of the spawning stock and eventually take remedial action if the stock is reduced beyond a minimum safe level. This can be done by comparing the cpue of several fleets and agreeing well in advance on a minimum safe abundance index below which the low catches for the given amount of effort are not worth the risk of

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overfishing and depleting the stock and, if this is agreed upon, the next step would be to stop the fishing season once this minimum safe level is reached.

As suggested before, this minimum safe spawners abundance index could be one corresponding to somewhere between 1.0 and 1.5 times the average cpue reported in the second part of the fishing seasons in 1980 and 1983, when apparently the spawning stock was the smallest recorded so far.

The main but not the only problem to overcome in managing this stock is that a variable proportion of it is distributed and can be exploited quite heavily on the offshore Patagonian Shelf and Slope area that falls beyond the 200 mile limit, between 41°50'S and 48°S, and where no national jurisdiction is recognized under the U.N. Convention on the Law of the Sea. Using data from fisheries surveys conducted between 1978 and 1981, FAO (1983) estimated that only 10 to 35% of the total biomass of shortfin squid was distributed in this area. However, it is noted that in this area the stock tends to form very dense concentrations that allow the fleet to obtain very high catch rates and total catches during the peak fishing season. Also, in the last two years, 45 to 50% of the total catches of shortfin squid were apparently caught in this fishing ground, and it is likely that these proportions could be increased if this remains as the only non-regulated fishing area in the region.

One other point to be taken into account is that an uncontrolled or unexpected increase in the total fishing effort in the above mentioned area will certainly obscure and can even cancel out the effects of possible management measures adopted in other areas. This could be particularly the case with respect to measures aiming at ensuring a greater spawning survival and in the years when, due to changes in the oceanographic conditions, the stock is distributed farther offshore. From the above it seems that, as indicated in Article 63, paragraph 2 of the U.N. Convention on the Law of the Sea, an adequate management of the shortfin squid stock will require the collaboration and some kind of understanding with the states fishing in the adjacent area.

5. OTHER RESOURCES AND ECOLOGICAL INTERACTIONS

Very little is known about the other fish resources in the area, partly because there have been no research programmes directed to these resources and, with the exception of the common squid, because there is no developed fishery directed to these species. These are mostly caught incidentally as by-catch in the other main fisheries, or eventually are exposed to a limited directed fisheries during very short periods of time on a non-regular basis.

Table 13

Estimated total biomass (thousand tons) of shortfin squid (Illex argentinus) by month in the South-West Atlantic, years 1978-85

Month	Biomass (thousand t)							
	1978	1979	1980	1981	1982	1983	1984	1985
December[1/]	-	93.0	19.8	26.5	111.3	68.6	105.3	98.5
January	-	136.9	26 2	40.1	150.7	92.1	110.5	131.7
February	-	176.9	34.3	51.2	166.0	113.9	117.8	171.0
March	-	214.9	41.1	56.1	195.3	137.4	164.0	181.0
April	209.6	260.5	44.7	77.7	237.0	143.0	164.1	184.6
May	251.8	295.3	49.7	79.2	209.2	86.5	151.5	171.5
June	289.3	333.4	43.0	69.2	185.0	52.5	105.2	118.9
July	274.6	364.0	45.5	68.1	205.0	34.4	71.7	73.1
August	-	366.3	46.6	67.7	194.9	35.4	60.4	61.7
September	-	110.8	6.6	3.4	40.9	3.3	.2	.2

1/ Previous year

Table 14

Estimated total biomass, biomass beyond 200 n mi north of 48°S and total catches by selected species[1/]

Species	Estimated total biomass ('000 t)[2/]	Proportion of biomass beyond 200 n mi. between 41°50'S and 48°S	Potential yield ('000 t)	Catch in 1981 (t)	Average annual catches 1983-1985 (t)	Catch in 1985 (t)
Macruronus magellanicus	350	0.3 - 5.0	65	2 300	10 690	21 828
Salilota australis	119	1.6 - 7.9	33	100	100	100
Macrourus whitsoni	71	11.6 - 57.8	39	531	19 441	9 221
Genypterus blacodes	222	3.1 - 11.8	19	4 699	8 520	10 552
Dissostichus eleginoides	39	1.7 - 15.9	7	409	139	195
Notothenia sp.	?	?	?	1 257	1 767	3 176
Loligo sp.	42	2.6 - 12.1	?	1 495	40 081	50 537

1/ Adapted from FAO (1983)
2/ From fishery resource surveys in 1981

Biomass estimates and potential yield estimates are available for only some of these other species, and are presented together with the estimates of their latest catches in Table 14. With respect to the state of exploitation of these resources, the general situation does not seem to have changed very much since the last review made in FAO (1983) except for the Patagonian whiphake (Macruronus magellanicus), the grenadier (Macrourus whitsoni) and the common squid (Loligo sp.) that have been captured in greater quantities in the last three years.

An offshore common squid fishery started to develop in 1982 and since then the total catches have increased to an average of 50 thousand tons/year. This stock is mainly exploited by Spain and the Soviet Union, that together made up more than 90% of the total catches of this species in the South-West Atlantic.

Other countries fishing for common squid are Bulgaria, Argentina and Japan. The fisheries apparently take place all year round and most of the offshore fishing takes place in the area around the Falkland Islands (Malvinas) and towards the north, in the offshore Patagonian Shelf and Slope between 42°S and 48°S. There are no reliable data from the fishery or from other sources to allow an assessment of the stock. However, in view of the relatively lower estimates of stock abundance in the past and the rapid development of this fisheries which, up to a given point has been following the development of the shortfin squid fisheries, it is most likely that the common squid stock be exposed to at least a similar state of exploitation than the shortfin squid.

Besides the one for common squid there seems to be no directed fisheries for any of the other species listed in Table 14. Estimates in this table indicate that the stock of grenadier (Macrourus whitsoni) is probably lightly to fully exploited while the Patagonian whiphake (Macruronus magellanicus), the Tadpole mora (Salilota australis), the pink cusk eel (Genypterus blacodes), the Patagonian toothfish (Dissostichus eleginoides), and the notothenids are all very lightly exploited. The grenadier is the only one that can mostly be found in the area of the offshore Patagonian Shelf and Slope that extends beyong the 200 nautical mile limit between 41°50'S and 48°S. All the other stocks are mostly found either around the Falkland Islands (Malvinas) or closer inshore on the Patagonian Shelf and Slope.

Apart from a general description of the trophic levels occupied by the main fish species or groups of species, very little is known about the species interactions in the area or with respect to possible changes in the distribution, behaviour and abundance of these species caused by the fisheries of other species or by changes in the environment.

Also, there is very little information and no assessment seems to be feasible for the time being regarding possible impacts of the offshore fishery on other marine populations in the area or on other parts of the ecosystem. Some cases of interactions and possible impacts of the fishery on populations of sea-birds, marine mammals and other marine animals and on the impacts of these populations on the fisheries have been reported in the literature for other parts of the world, but in most of the cases reported there are no clear indications on whether the changes on the marine populations have actually been caused by the fishery (directly or by exploiting other fish resources in the same area), by other human activities, by changes in the oceanographic and climatic conditions, or by other changes in the environment.

Fishing, as any other imposed cause of mortality on living resources will certainly have an impact on the ecosystem but, unless the resources are overexploited or depleted there seems to be no reason to expect that the offshore fishing pressure in the South-West Atlantic will have a greater impact on the ecosystem in the area than the one by other fisheries of similar characteristics had in other parts of the world. This, however, is by no means a reassurance that fishing does not have or will not have an impact on the state of the ecosystem and of other marine populations in the South-West Atlantic.

By reducing the stock size of prey species the fisheries will certainly cause the predatory species to lose a share of its available food supply, and if they are not capable of replacing this part of their diet, the predator species will be left with the only alternative of accommodating their own overall abundance to the new abundance of prey species.

This direct type of competition between the fisheries and other marine populations may have a noticeable effect on species that are highly dependent on a single source of food, as in the case of some sea-birds. For instance, the cormorants along the Peruvian coast feed almost exclusively on schooling anchovies and were almost depleted when the anchovy fishery collapsed, while pelicans and boobies in the same area were apparently not affected. On the contrary, they were able to adapt their diet to the new situation and even started to increase after some years (Tovar, 1983).

Some references are also made to this type of fisheries interactions with marine mammals, but as pointed out by Northridge (1984) there are very few cases of competition between fisheries and marine mammal populations that have been clearly identified or quantified.

Other types of interactions between the fishery and other marine populations include the incidental capture of marine mammals and, to a lesser extent, sea-birds by the fishing gears. So far, there are no

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reports indicating that this type of interactions occur or could be an important source of mortality of these populations in the South-West Atlantic. There are no indications either of possible adverse effects on the fisheries caused by other marine populations.

6. SUMMARY AND CONCLUSIONS

Four offshore fisheries have been identified in the area: the common hake fishery, the southern blue whiting fishery, the shortfin squid fishery and the common squid fishery. Other species that are reported in the catches of offshore fleets operating in the area are apparently caught in the course of fishing operations directed to one of the four species mentioned above, although in some cases they may also be caught in the course of short-term and sporadic fishing operations conducted outside one of these four main fisheries.

The common hake fishery mostly takes place in the area off the River Plate basin and in the northern Patagonian Shelf. The stock is shared by Argentina and Uruguay who are also the only countries exploiting this resource. The stock seems to be moderately to fully exploited and management measures are discussed and could be implemented under the terms of reference of the Argentinian-Uruguayan Joint Technical Commission for the Maritime Front established in 1973.

Southern blue whiting is mostly distributed over the continental shelf and Slope around the Falkland Islands (Malvinas) where most of the current catches are taken by Polish and Soviet fleets. The stock seems to be lightly to moderately exploited and the fisheries are mostly concentrated on a few relatively old and abundant year classes. No fishing effort seems to be directed to juveniles and the fishing effort directed to the already mature younger adults seems also to be very small. This type of fishing pattern contributes to preserve at least part of the spawning stock and reduces the risk of both recruitment overfishing and of growth overfishing.

Assessments of the southern blue whiting made by Virtual Population Analysis and Yield per Recruit analysis indicate that, provided the same fishing pattern is maintained, fishing intensity could be increased by as much as 60 to 80% over the recent average level for 1983-85 without affecting the continuity and conservation of the resource which, at present, does not seem to be at risk.

From the above, it might be concluded that for the time being, no management measures are urgently needed to protect the stock. However, if fishing intensity increases beyond a certain limit, say if fishing effort doubles with respect to the current 1983-85 level or if the fishing pattern is changed in such a way that fishing pressure increases on younger adults or on juveniles, then some management measures might have to be adopted particularly in the area of the Patagonian Shelf and Slope around the Falkland Islands (Malvinas),

where around 90% of the estimated exploitable stock has been found in past fishery resources surveys and where most of the current catches are taken.

The Virtual Population Analysis and the Yield per Recruit analysis are relatively simple and generally accepted methods for the assessment of the state of exploited fish stocks, and the results presented in this report could easily be updated and improved as more data become available, thus providing an adequate scientific basis on which management measures could be decided in the future. For an adequate monitoring of the southern blue whiting stock the minimum requirements are that every year, at the end of the fishing season, reliable estimates be provided of the age-frequency distribution of the southern blue whiting caught by each major fleet and country, and of the total catches and fishing effort, indicating as far as possible the general location of the main fishing grounds.

Shortfin squid is distributed and can be caught in four main fishing areas: the River Plate basin area and the northern Patagonian Shelf and Slope, where it is mostly caught by Argentina and Uruguay; the inshore Patagonian Shelf area between 40°S and 47°S, where some limited amounts are caught by Argentina; the offshore Patagonian Shelf and Slope area between 42°S and 48°S, where very high concentrations usually occur and is exploited by almost all the offshore fleets fishing for squids in the area; and the Patagonian Shelf and Slope around the Falkland Islands (Malvinas) where also very high concentrations occur and is exploited by most of the offshore fishing fleets.

The productivity of each of these fishing grounds is related to the seasonal migration of the shortfin squid and to the overall abundance of the stock, which is highly variable from one year to another. So far there is no evidence of the existence of more than one identifiable separate population and it is assumed that all the shortfin squid caught in the above four main fishing grounds belong to a single main stock.

Most of the stock is composed of a single year class that is recruited in January-February and then dies shortly after spawning in July-September the same year. A second group that spawns in summer represents a very small proportion of the total current catches. The duration and productivity of the fishing season is closely related to the strength of the year class that spawns in winter.

Information available indicates that until 1985 the shortfin squid stock has been reasonably exploited in the sense that the yields obtained were very close to the maximum obtainable while the spawning stock survival was reduced to levels that do not seem to have placed the conservation of the stock in serious danger. However, preliminary information indicates that the overall fishing effort directed to

shortfin squid may have been increased during the 1986 fishing season by at least 60% above the average level of 1983-85. This may have driven the stock into an overfishing situation, particularly if, as it seems, the recruitment strength was not particularly high.

A spawning stock size similar or slightly higher than that of 1980 and 1983 is suggested as a possible benchmark for setting a minimum safe stock size beyond which no fishing should be allowed in order to guarantee the conservation of the stock and prevent the risk of recruitment overfishing. It is suggested that this minimum safe level be set somewhere between 1 and 1.5 times the average spawning stock level in 1980 and 1983, which corresponds to the lowest spawning stock sizes recorded so far. Fishery resources surveys, exploratory fishing or, even better, the monthly or weekly catch per unit of effort of the commercial fleet could be used to monitor the abundance of the spawning stock and to ensure that this is not reduced below the suggested minimum safe level.

The shortfin squid stock has shown wide fluctuations in past years due to recruitment variability and this variability should be accounted for when judging the state of exploitation of the stock and in possible attempts to regulate the fishery, particularly if the aim is to satisfy the objectives of maximizing the annual total yields and at the same time preventing the eventual depletion of the resource and collapse of the fishery. This implies that fishing mortality and fishing effort should vary with recruitment strength.

A variable fishing mortality or fishing effort policy regulation will allow fishing to increase whenever the abundance of the stock increases (e.g., due to stronger year classes) and will tighten the protection of the stock by reducing the amount of fishing effort in poor years when, for instance, recruitment is low. It seems that this approach could be applicable to the shortfin squid fisheries, provided the countries concerned agree to regulate the amount of fishing effort directed to this species.

The available information suggests that, under this approach, fishing effort could safely be increased to a level 30% higher than the average 1983-85 level when recruitment is as high as in 1982 and 1984, and that fishing effort would have to be reduced to 50% of the average 1983-85 level, if recruitment is as poor as in 1980 and 1981.

Good and reliable information would be required on a continued basis to implement this or any other management alternative and there are several ways to monitor the state of the resource and obtain information on the fisheries that would allow timely detection of possible changes that may justify the adoption of management measures.

Trying to estimate recruitment strength early in the fishing season seems one of the main objectives of any research programme in

support of the management of the shortfin squid fishery. This can be done through fishery resources surveys, exploratory fishing or by monitoring the catch by unit of effort of the commercial fleet early in the season. Another objective will be to monitor the abundance of the stock late in the fishing season to ensure that the spawning stock is not reduced below a minimum safe level.

Several operational problems are identified with respect to monitoring and estimating the state of the resource, and particularly with respect to the possibilities of adopting feasible management measures. The main but not the only one is that a variable proportion of the stock is distributed and can be exploited quite heavily on the part of the offshore Patagonian Shelf and Slope located between 41°50'S and 48°S that falls beyond the 200 mile limit from the coast, and thus outside national jurisdiction.

It is estimated that on average 10 to 35% of the total biomass of shortfin squid might be distributed in this offshore area, where the stock tends to concentrate heavily during the peak fishing season. It was estimated that in the last two years 45 to 50% of the total catches of shortfin were caught in this offshore fishing ground, while 40 to 45% of the catches were taken in the area around the Falkland Islands (Malvinas) and something between 10 and 20% were taken in the area off the River Plate basin and the northern and inshore Patagonian Shelf.

It is also noted that the effects of possible management measures adopted in one or more of these areas may be obscured and even be cancelled out by a sudden and uncontrolled increase in fishing effort in any of the other fishing areas. This would be particularly the case with respect to measures aiming at ensuring a greater spawning survival or when the oceanographic conditions force the stock to concentrate in non-regulated areas.

From this, it seems that an adequate management of the shortfin squid stock will require some kind of collaboration among the states operating in the area. In this respect it is underlined that the shortfin stock falls precisely under the terms of Article 63, paragraph 2 of the U.N. Convention on the Law of the Sea that reads: "Where the same stock or stocks of associated species occur both within the exclusive economic zone and in an area beyond and adjacent to the zone, the coastal State and the States fishing for those stocks in the adjacent area shall seek either directly or throughout appropriate subregional or regional organizations to agree upon measures necessary for the conservation of these stocks in the adjacent area."

Another important fishery in the area is the one for common squid for which very little information is available from the fishery, making it impossible to produce an adequate assessment. However, from

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the results of past fishery resources surveys and the comparison with the estimated current total catches, and some other sparse information, it seems that this stock would be fully exploited with a high probability of becoming overexploited.

No detailed information was available for the other fish resources, mainly because there are no fisheries directed at them. However, from the total catch data available and background information from past fishery resources surveys, it seems that these stocks are lightly exploited and as long as they do not become main targets of the long-range fleets operating in the area there should be no great danger for these stocks becoming overfished or depleted.

With respect to the possible effects of the fisheries on the ecosystem and on other marine populations, the information is too scarse to allow an adequate assessment. However, it is pointed out that under the present circumstances there is little likelihood that the offshore fishing pressure in the South-West Atlantic will have a greater impact on the ecosystem of this area than that produced by other fisheries with similar characteristics in other parts of the world.

7. REFERENCES

Beddington, J.R., S. Brault and J.A. Gulland, 1985. The fisheries around the Falklands. London, Imperial College, IIED/IUCN; Marine Resources Assessment Group, 53 pp. (mimeo)

Beverton, R.J.H., and S.J. Holt, 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Rapp.P.-V.Réun.CIEM, 140(1):67-83

Caddy, J.F. (ed.), 1983. Advances in assessment of world cephalopod resources. Progrès réalisés dans l'évaluation des ressources mondiales de céphalopodes. Progresos realizados en la evaluación mundial de cefalópodos. FAO Fish. Tech.Pap./FAO,Doc.Tech.Pêches/FAO,Doc.Téc.Pesca, (231): 452 p.

_____, 1983a. The cephalopods: Factors relevant to their population dynamics and to the assessment and management of stocks. In Advances in assessment of world cephalopod resources. FAO Fish.Tech.Pap./FAO,Doc.Tech.Pêches/FAO,Doc. Téc.Pesca, (231):416-49

Coehlo, M.L., 1985. Review of the influence of oceanographic factors on cephalopod distribution and life cycles. Sci.Coun.Stud. NAFO, (9):47-57

Csirke, J., 1980. Recruitment in the Peruvian anchovy and its dependence on the adult population. Rapp.P.-V.Réun.CIEM, 177:307-13

_____, 1984. Report of the Working Group on fisheries management, implications and interactions. FAO Fish.Rep.,(291) Vol.1:67-90 Issued also in French and Spanish

FAO, Marine Resources Service, Fishery Resources and Environment Division, 1979. Review of the state of world fishery resources. FAO Fish.Circ., (710)Rev.1:41 p. Issued also in French, Spanish, Arabic and Chinese

_____, 1981. Review of the state of world fishery resources. FAO Fish.Circ., (710)Rev.2:52 p. Issued also in French, Spanish, Arabic and Chinese

FAO, 1983. Informe del Grupo Ad hoc de Trabajo sobre los recurso pesqueros de la plataforma continental patagónica. Roma, 7-11 Febrero 1983. Una reunión preparatoria para la conferencia mundial de la FAO sobre Ordenación y Desarrollo Pesquero. Report of the Ad hoc Working Group on fishery resources of the Patagonian Shelf. Rome, 7-11 February 1983. A preparatory meeting for the FAO World Conference on fisheries management and development. FAO Inf.Pesca/FAO Fish.Rep., (297):83 p.

_____, Marine Resources Service, Fishery Resources and Environment Division, 1985. Review of the state of world fishery resources. FAO Fish.Circ., (710)Rev.4:61 p. Issued also in French, Spanish, Arabic and Chinese

Garcia, S., and L. Le Reste, 1981. Life cycles, dynamics, exploitation and management of coastal penaeid shrimp stocks. FAO Fish.Tech.Pap., (203):215 p. Issued also in French and Spanish

Hatanaka, H., 1986. Growth and life span of short-finned squid Illex argentinus in the waters off Argentina. Bull.Jap.Soc.Fish. 52(1):11-7

Hatanaka, H., et al., 1985. Comparison of life cycles of five Ommastrephid squids fished by Japan: Todarodes pacificus, Illex illecebrosus, Illex argentinus, Nototodarus sloani sloani and Nototodarus sloani gouldi. Sci.Counc.Stud.NAFO, (9): 59-68

Hoenig, J.M., 1983. Empirical use of longevity data to estimate mortality rates. Fish.Bull.NOAA/NMFS, 81(4):898-903

ICNAF, 1978. Report of Standing Committee on research and statistics (STACRES) Special meeting on squid. February 1978. ICNAF Redbook, (1978):23-33

Inada, T., and I. Nakamura, 1978. A comparative study of two populations of the gadoid fish, Micromesistius australis, from the New Zealand and Patagonian-Falkland regions. Bull.Far. Seas Fish.Res.Lab., (13):1-26

Koronkiewicz, A., 1986. Growth and life cycle of the squid Illex argentinus from the Patagonian shelf and Polish squid fishery in the region, 1978-85. Gdynia, Sea Fisheries Institute, 9 p. + 14 figures + 12 tables (mimeo)

Liwoch, M., 1986. Polish catches and fishing effort on the Patagonian Shelf and off the Falklands-Malvinas (FAO Division 41, subdivision 38°S and 50°W) in the years 1978-1985. Gdynia, Sea Fisheries Institute, 3 p. + 8 tables (mimeo)

_____, 1986a. Information concerning the results of Polish biological and fishery investigations of southern poutassou (Micromesistius australis, Norman, 1937) on the Patagonian shelf and Falkland Islands (Malvinas) in the years 1981-1985. Gdynia, Sea Fisheries Institute, 6 p. + 13 figures + 27 tables (mimeo)

MacCall, A.D., 1980. Population models for the northern anchovy (Engraulis mordax). Rapp.P.-V.Réun.CIEM, 177:292-306

Malaret, A.E., et al., 1986. Impacto ecológico y económico de las capturas alrededor de las Malvinas después de 1982. Informe preparado en el Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata, Argentina, Marzo 1986, 154 p. (mimeo)

Mikheyev, B.I., 1967. On the biology and fisheries of certain fishes from the Patagonian Shelf (Falkland Region) and the Scotia Sea. In Soviet fishery research on the Antarctic krill edited by R.N. Burukovskiy. Kaliningrad, Atlantic Scientific Research Institute for Fisheries cc and ddd Oceanography. Issued also by the U.S. Department of Commerce, Clearinghouse for Federal Scientific and Technical Information, Washington, D.C., (TT:67-32683): pp.85-93

Marine Resources Assessment Group, (MRAG), 1986. Fisheries around the Falklands: Interim report, 1 (February 1986). London, Imperial College, 10 p. (mimeo)

_____, 1986a. Fisheries around the Falklands: Interim report 2 (March 1986). London, Imperial College, 26 p. (mimeo)

_____, 1986b. Fisheries around the Falklands: Interim report 3 (August 1986). London, Imperial College, 42 p. + tables and figures (mimeo)

_____, 1987. Fisheries around the Falklands. Interim report, 4 (February 1987). London, Imperial College, 21 p. (mimeo)

NAFO, 1980. Report of Standing Committee on fishery science (STACFIS). NAFO Sci.Counc.Rep., (1979-80):43-60

Northridge, S.P., 1984. World review of interactions between marine mammals and fisheries. FAO Fish.Tech.Pap., (251):190 p. Issued also in French and Spanish

Otero, H.O., et al., 1982. Atlas de los recursos pesqueros demersales del mar argentino. Contrib.Inst.Invest.Desarr. Pesq., Mar del Plata, (423):248 p.

Otero, H.O., and G. Verazay, 1984. Comportamiento de los modelos de produción excedente (surplus) en la población de merluza común (Merluccius hubbsi). El modelo lineal y el modelo exponencial. Physis (A), 42(102):17-24

Patterson, K., 1986. A preliminary stock assessment for Illex argentinus in the Falkland Islands protection zone in 1985. Falkland Islands Development Corporation, 35 p. (mimeo)

Pauly, D., 1981. On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J.Cons.CIEM., 39(2):175-92

Perotta, R.G., 1982. Distribución y estructura poblacional de la polaca (Micromesistius australis). Rev.Invest.Desarr. Pesq.Mar del Plata, (3):35-50

Rickhter, V.A., and V.N. Efanov, 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res.Doc. 76/VI/8:12 p. (mimeo)

Shpak, V.M., and V.V. Kuchina, 1983. Dynamics of abundance of southern poutassu. Sov.J.Mar.Biol., 8(2):81-4

Tovar, H., 1983. Fluctuaciones de poblaciones de aves guaneras en el litoral peruano, 1960-1981. FAO Fish.Rep/FAO Inf.Pesca, (291)Vol.3:957-76

Zukowski, C., and M. Liwoch, 1977. Biologia i polowy blekitka poludniowego (Micromesistius australis, Norman) z szelfu patagonskiego. Biologia i zasoby ryb szelfu argentynskiego. Stud.Mater.Morsk.Inst.Ryb.Gydnia (Ser. B), (49):5-52

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